APPENDIX C
REFERENCE CONDITION APPROACH

This appendix presents details about the general and statistical methods used for development of reference conditions.

C.1 Reference Condition

DEQ uses the reference condition to evaluate compliance with many of the narrative WQS. The term “reference condition” is defined as the condition of a waterbody capable of supporting its present and future beneficial uses when all reasonable land, soil, and water conservation practices have been applied. In other words, the reference condition reflects a waterbody’s greatest potential for water quality given historic land use activities.

C.1.1 Reference Condition as Defined in DEQ’s Standard Operating Procedure for Water Quality Assessment (2006b)

DEQ applies the reference condition approach for making beneficial use-support determinations for certain pollutants (such as nutrients) that have narrative standards. Montana’s WQS do not contain specific provisions addressing nutrients, yet nutrients are known to adversely affect beneficial uses under certain conditions or combination of conditions. The reference condition approach is used to determine if beneficial uses are supported when nutrients are present.

Waterbodies used to determine reference condition are not necessarily pristine or perfectly suited to giving the best possible support to all possible beneficial uses. Reference condition also does not reflect an effort to turn the clock back to conditions that may have existed before human settlement, but is intended to accommodate natural variations in biological communities, water chemistry, etc. due to climate, bedrock, soils, hydrology, and other natural physiochemical differences. The intention is to differentiate between natural conditions and widespread or significant alterations of biology, chemistry, or hydrogeomorphology due to human activity. Therefore, reference conditions should reflect minimum impacts from human activities. A reference approach attempts to identify the potential condition that could be attained (given historical land use) by the application of reasonable land, soil, and water conservation practices. DEQ realizes that presettlement water quality conditions usually are not attainable.

Comparison of conditions in a waterbody to reference waterbody conditions must be made during similar seasons and/or hydrologic conditions for both waters. For example, the Total Phosphorus (TP) concentration in a stream at base flow during the summer should not be compared to the TP reference condition that would occur during a spring runoff event. In addition, a comparison should not be made to the lowest or highest TP values of a reference site, which represent the outer boundaries of reference conditions.

The following approaches may be used to determine reference conditions:

Primary Approach
- Comparing conditions in a waterbody to baseline data from minimally impaired waterbodies that are in a nearby watershed or in the same region having similar geology, hydrology, morphology, and/or riparian habitat.
- Evaluating historical data relating to condition of the waterbody in the past.
- Comparing conditions in a waterbody to conditions in another portion of the same waterbody, such as an unimpaired segment of the same stream.

Secondary Approach
- Reviewing literature containing reports of aquatic life or macroinvertebrate assessments or studies using other indicators of stream health that were conducted on similar waterbodies that are minimally impaired.
- Seeking expert opinion (e.g. from a regional fisheries biologist who has a good understanding of the waterbody's fisheries health or potential).
- Applying quantitative modeling (e.g. applying a nutrient loading model to determine how much nitrogen or phosphorus is entering a stream based on land use and land cover characteristics).

DEQ uses the primary approach for determining reference condition if adequate regional reference data are available and uses the secondary approach to estimate reference condition when there are no regional data. DEQ often uses more than one approach to determine reference condition, especially when regional reference condition data are sparse or nonexistent.

C.1.2 Use of Statistics for Developing Reference Values or Ranges

Reference value development must consider natural variability as well as variability that can occur as part of field measurement techniques. Statistical approaches are commonly used to help incorporate variability. One statistical approach is to compare stream conditions to the mean (average) value of a reference data set to see if the stream condition compares favorably to this value or falls within the range of one standard deviation around the reference mean. The use of these statistical values assumes a normal distribution, whereas water resources data tend to have a non-normal distribution (He1sel and Hirsch 1995). For this reason, another approach is to compare stream conditions to the median value of a reference data set to see if the stream condition compares favorably to this value or falls within the range defined by the 25th and 75th percentiles of the reference data. This is a more realistic approach than using one standard deviation since water quality data often include observations considerably higher or lower than most of the data. Very high and low observations can have a misleading impact on the statistical summaries if a normal distribution is incorrectly assumed, whereas statistics based on non-normal distributions are less influenced by such observations.

Figure C-1 is an example boxplot type presentation of the median, 25th and 75th percentiles, and minimum and maximum values of a reference data set. In this example, the reference stream results are stratified by two different stream types. Typical stratifications for reference stream data may include stream gradient categories, stream size ranges, or geomorphic settings. If the parameter being measured is one where low values are undesirable and can cause harm to aquatic life (such as dissolved oxygen), then measured values in the potentially impaired stream that fall below the 25th percentile of reference data are not desirable and can be used to indicate impairment. If the parameter being measured is one where high values are undesirable (such as nutrient concentrations), then measured values above the 75th percentile can be used to indicate impairment.

The use of a non-parametric statistical distribution for interpreting narrative WQS or developing numeric criteria is consistent with EPA's guidance for determining nutrient criteria (EPA 2000). Furthermore, the selection of the applicable 25th or 75th percentile values from a reference data set is consistent with ongoing DEQ guidance development for interpreting narrative WQS where it is determined that there is "good" confidence in the quality of the reference sites and resulting information (Suplee 2004). If there is only a "fair" confidence in the quality of the reference sites, then the 50th percentile or median value is preferred. If there is "very high" confidence, then the 90th percentile of the reference data set should be used. Most available sets of reference data for TMDL target development tend to be of "fair" to "good" quality. This is primarily due to the limited number of available reference data points after applying geographic and seasonal stratifications. Reference data quality can also be affected by field crew experience, sampling methods, short-term land use changes and other annual stream system changes not often accounted for in an individual data set.

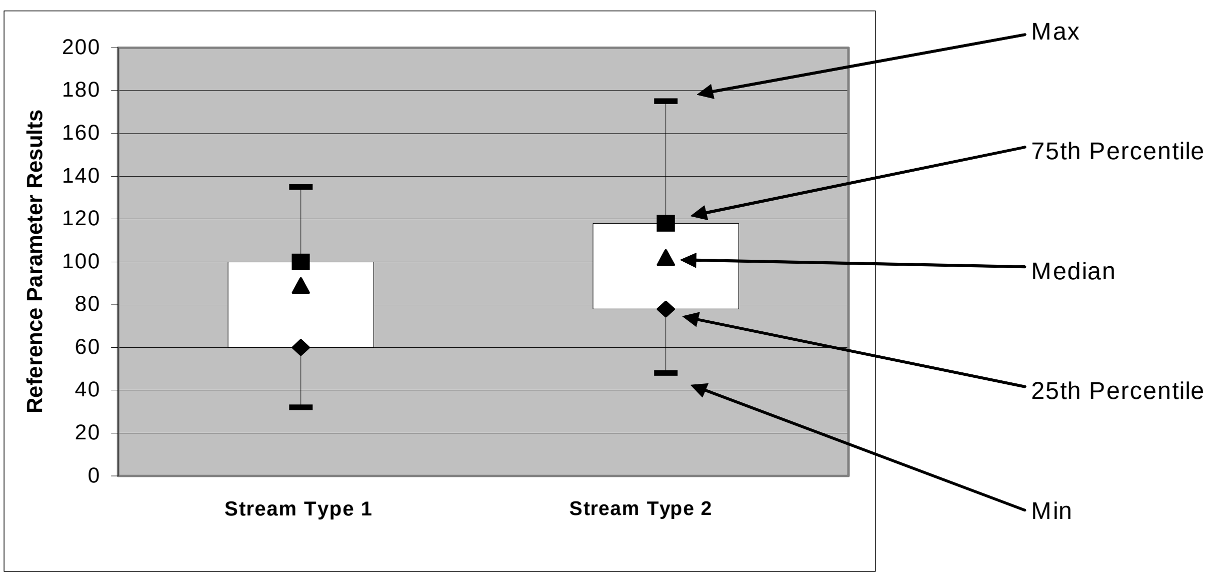

Figure C-1. Boxplot Example for Reference Data.

The above 25th – 75th percentile statistical approach has several notable considerations:

1. It is a simple approach that is easy to apply and understand.
2. About 25 percent of all streams would naturally fall into the impairment range. Thus, it should not be applied unless there is some linkage to human activities that could lead to the observed conditions. Where applied, it must be noted that the stream's potential may prevent it from achieving the reference range as part of an adaptive management plan.

3. About 25 percent of all streams would naturally have a greater water quality potential than the minimum water quality bar represented by the 25^{th} to 75^{th} percentile range. This may represent a condition where the stream's potential has been significantly underestimated. Adaptive management can also account for these considerations.
4. Obtaining reference data that represents a naturally occurring condition can be difficult because all reasonable land, soil, and water conservation practices may not be extensively in use. Even if these practices are in place, the proposed reference stream may not have fully recovered from past activities, such as continuous, season-long livestock grazing that does not represent application of all reasonable land, soil, and water conservation practices.
5. A stream should not be considered impaired unless there is causal linkage between the parameter of concern and beneficial use support. That is, if the reference range for a water quality parameter is not met, negative impacts to beneficial uses are likely. Causal relationships between target parameters and beneficial uses can justify impairment conclusions based on the above statistical approach.

There are two types of errors that can occur due to this or similar statistical approaches where a reference range or reference value is developed: (1) A stream could be considered impaired even though the naturally occurring condition for that stream parameter does not meet the desired reference range or (2) a stream could be considered not impaired for the parameter(s) of concern because the results for a given parameter fall just within the reference range, whereas the naturally occurring condition for that stream parameter represents much higher water quality and beneficial uses could still be negatively impacted. The application of adaptive management helps to minimize a sustained error of either type.

Options When Regional Reference Data is Limited or Does Not Exist

In some cases, there is very limited reference data and applying the above statistical approaches is not possible. Under these conditions the limited information can be used to develop a reference value or range, with the need to note the greater level of uncertainty and perhaps a greater level of future monitoring as part of the adaptive management approach. These conditions can also lead to more reliance on secondary type approaches for reference development as described above in **Section C.1.1**.

An alternative approach is to develop summary statistics for a given parameter from all streams within a watershed or region of interest (EPA 2000). The boxplot distribution of all the data for a given parameter is still useful to help determine potential target values, realizing that most or all of the streams being evaluated are either impaired or have a reasonable probability of having significant water quality impacts. Under these conditions one would apply the median and the 25^{th} or 75^{th} percentiles as potential target values, but you would use the 25^{th} and 75^{th} percentiles in a way opposite from their use as a true regional reference distribution. Where the distributional statistics summarize the entire data set, one could reasonably assume that as many as 50% to 75% of the results represent questionable water quality.

Figure C-2 below illustrates an example of a statistical distribution for which higher values represent better water quality. In this case, the median and 25^{th} percentiles may represent potential target values, versus the median and 75^{th} percentiles discussed above for a higher quality reference distribution. Justification for use of the median, the 25^{th} percentile, or both should be based on an assessment of the level of impact to all measured streams in the watershed.

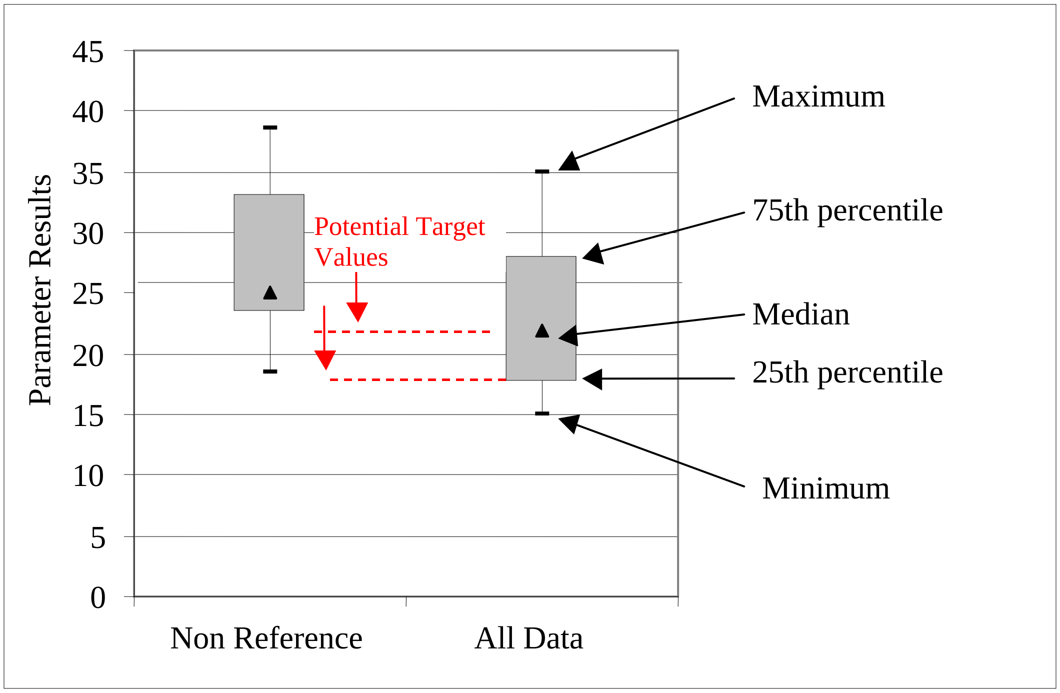

Figure B-2. Boxplot example for the use of all data to set targets.

Focused consideration of target achievability is important when using this approach. There may also be a need to rely on secondary reference development methods to modify how one applies the target or what one selects as the final target value. The level of certainty in impairment conclusions may be lower using the all-data approach, and adaptive management may have a larger role in TMDL implementation.

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