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A Framework for Defining and Documenting Natural Conditions for Development of Site-Specific Natural Background Aquatic Life Criteria for Temperature, Dissolved Oxygen, and pH: Interim Document

EPA DISCLAIMER

The Environmental Protection Agency (EPA) produced this document to assist states and authorized tribes interested in defining natural conditions in the development of scientifically-defensible site-specific aquatic life criteria for three water quality parameters: temperature, dissolved oxygen (DO), and pH. This document is not intended to provide technical or policy advice on how to address impacts of global climate change on the three parameters of interest (temperature, DO, and pH) during water quality criteria development. States and authorized tribes can use the information presented in this document to support the identification and documentation of natural conditions and development of site-specific criteria for temperature, DO, and pH. Simply because the EPA is providing this document does not guarantee or imply tacit EPA approval or acceptance of the decisions, results, and/or conclusions drawn from this work. Any implications on or changes to state or tribal water quality standards as a result of this work may be subject to Clean Water Act (CWA) Section 303 review and approval or disapproval by the EPA.

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1. INTRODUCTION

This document is intended as a framework to assist states and authorized tribes in developing a consistent, transparent, and scientifically-defensible approach for identifying and characterizing natural conditions, which will specifically inform the development of site-specific criteria (SSC) for temperature, dissolved oxygen (DO), and pH for the protection of aquatic life designated uses. SSC derivation procedures can be found in Chapter 3 of the EPA's Water Quality Standards Handbook (USEPA, 1994). As long as the SSC are scientifically defensible and protective of the designated use, the resulting criteria could be more or less stringent than the adopted criteria and still meet CWA requirements.[1]

The EPA's current national policy regarding the establishment of site-specific natural background criteria recommends that interested states and authorized tribes establish site-specific numeric aquatic life criteria by setting the criteria value equal to *natural background*, where natural background is defined as due *only* to non-anthropogenic sources (i.e., non-human-induced sources)[see Appendix A: http://water.epa.gov/scitech/swguidance/standards/upload/2009_01_29_criteria_naturalback.pdf (USEPA, 1997)]. In doing this, states and authorized tribes should include the following in their water quality standards:

(1) a definition of natural background consistent with the above;
(2) a provision that site-specific criteria may be set equal to natural background;
(3) a procedure for determining natural background, or alternatively, a reference in their water quality standards to another document describing the binding procedure that will be used.

With limited national guidance, states and regions have taken different approaches to characterize natural conditions for development of aquatic life criteria for temperature, DO and pH. Given that human disturbance is generally widespread and may be pervasive in some areas, and that environmental data indicate a high degree of temporal and spatial variability, separating out what is natural from anthropogenic, as well as accurately characterizing natural sources, can be challenging. In recognition of these challenges, the EPA has created this recommended framework as one way to assist states and authorized tribes that are interested in considering natural conditions in the development of scientifically defensible aquatic life SSC for temperature, DO, and pH. As outlined below and shown in Figure 1, there are five major parts to this framework.

(3.1) Determine whether a natural background criterion is appropriate;
(3.2) Determine whether non-attainment of the water quality criterion is due to natural processes;
(3.3) Determine the spatial and temporal boundaries of the natural background criterion;
(3.4) Calculate a natural background criterion; and
(3.5) Adopt natural background criterion.

[1] http://water.epa.gov/scitech/swguidance/standards/handbook/chapter03.cfm#section7

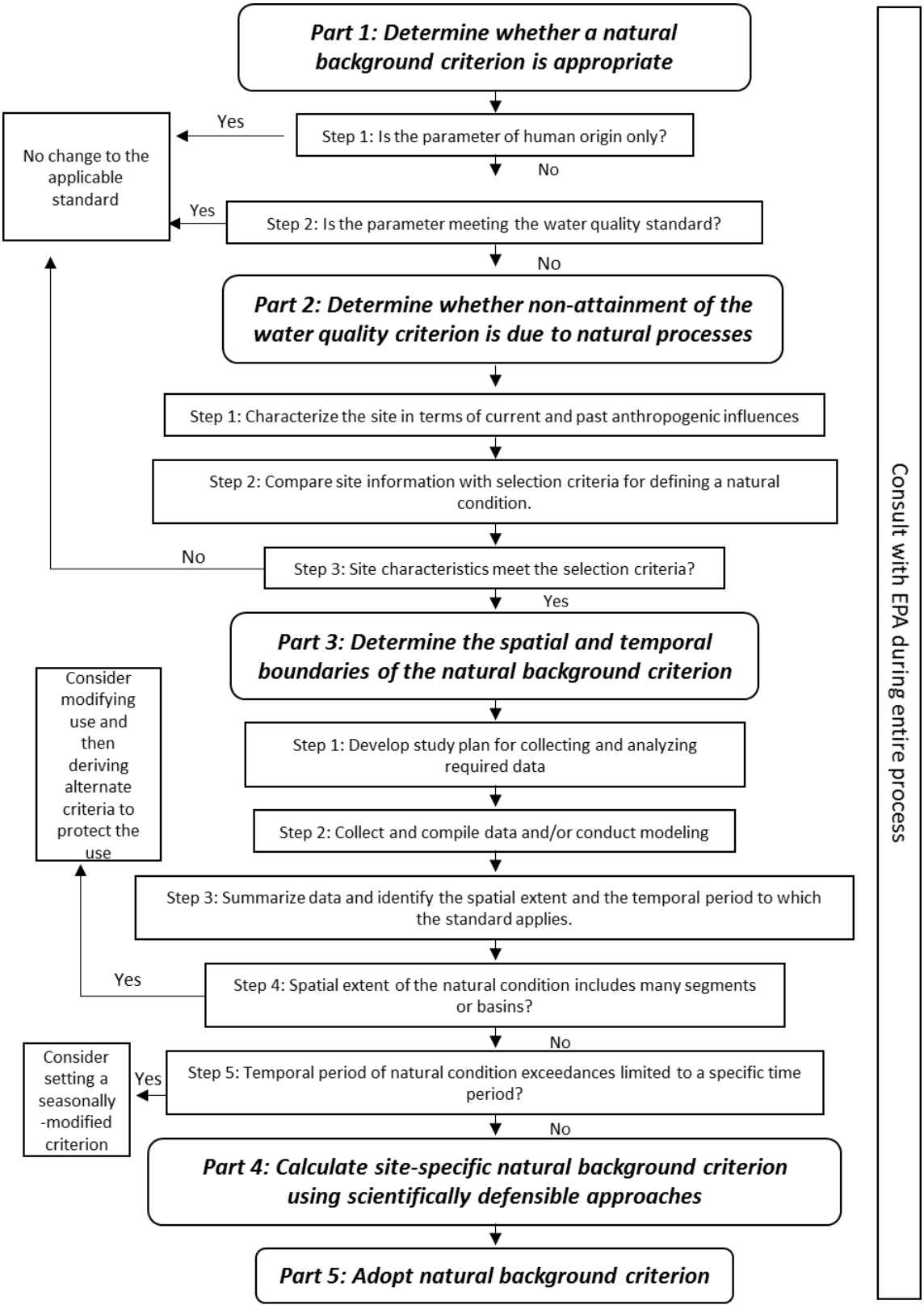

Figure 1. Process for identifying and documenting a natural condition for temperature, DO, and pH

2. CONTEXT

The EPA has developed and published national recommended ambient water quality criteria, pursuant to Section 304(a) of the CWA, for a range of anthropogenic and naturally-occurring constituents that have the potential to impact aquatic life uses.[2] Three important natural constituents in water related to aquatic life that serve as the focus of this framework are temperature, DO, and hydrogen ions (pH). Early federal efforts to derive recommended criteria for these constituents were premised on the use of literature reviews and the collective scientific judgment of the EPA and advisory panels. The EPA's "Red Book" (USEPA, 1976) contains recommended pH criteria and the EPA's "Gold Book" (USEPA, 1986) contains recommended criteria for DO and temperature. The basis of these criteria is scientific literature capturing fisheries lab and field studies performed from 1930-1980. Typically, states and authorized tribes have adopted these criteria and implemented them for the protection of general aquatic life uses.

When a state or authorized tribe designates a single "generalized" aquatic life use for its waters, the use may not adequately capture the unique or complex chemical, physical, or biological characteristics that exist in a particular system. Having a single generalized aquatic life use, combined with a complex natural ecology throughout a state or tribal land, may result in inconsistencies between water quality and biological assessment results. For example, assessment of certain water quality criteria (e.g., pH) for any given water body may suggest impairment while other applicable indicators (e.g., biological assessment) suggest that uses are being met. In some of these cases, the inconsistency may be due to natural processes at a site that prevent the attainment of the applicable water quality criterion adopted to protect a generalized aquatic life use. As a result, statewide water quality criteria adopted to protect the generalized aquatic life use should be further refined through adoption of SSC, to protect unique characteristics inherent to a specific water. In adopting SSC due to natural conditions, states and authorized tribes must ensure the SSC are protective of the use, which may result in more or less stringent criteria.

Two possible options that states and authorized tribes could use to incorporate natural conditions in their water quality standards (WQS) include: 1) developing and adopting into rule site-specific natural background water quality criteria as an alternative value to a statewide, or otherwise applicable, water quality criteria; and/or 2) refining/subcategorizing the designated aquatic life uses in the state WQS and developing water quality criteria that protect those new uses. This paper focuses on the first option. EPA recognizes there are naturally-occurring concentrations of pollutants that may exceed the EPA's national criteria published under section 304(a) of the CWA. Site-specific natural background criteria are best used when additional scientific consideration can bring added accuracy to expressing an appropriate level for a water quality parameter to protect a designated use. As long as the SSC are protective of the same designated use, there is no need to modify the designated use or conduct a use attainability analysis.

[2] To access a table summarizing EPA's national recommended aquatic life criteria visit: http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm.

Regarding the second option, there is a well-established framework developed by the EPA's Chesapeake Bay Program Office that can aid states and authorized tribes in refining their aquatic life use structures (USEPA, 2003; USEPA, 2010; Batiuk et al. 2009). Both options, developing SSC and/or refining designated uses, ultimately require the development of new criteria; they simply represent different pathways to achieve that goal.

3. Procedure for Development of Water Quality Criteria Based on Natural Background

To develop defensible, transparent, and consistent natural background criteria, it is beneficial to outline a framework by which a given parameter can be evaluated in a particular area influenced by natural conditions. As part of this process, the natural condition for a parameter (i.e., temperature, pH, or DO) is characterized by analyzing data relevant to that situation. Such data are subsequently used to establish SSC applicable to that particular situation. As described above, there are five general parts to the process as shown in Figure 1.

Within each of these five parts of the process is one or more suggested steps that are designed to help determine: 1) whether a natural background criterion is appropriate in the first place; 2) whether the observed parameter measurements are indeed the result of natural processes; and 3) the site boundaries and temporal dynamics to which a natural background criterion should apply. Note that this procedure is focused on characterizing natural conditions and developing natural background criteria in cases where the parameter of interest is not meeting the applicable criterion, but there is evidence that the aquatic life designated use(s) is (are) still being protected. This procedure could also be used to derive a site-specific natural background criterion in cases where the parameter of interest is meeting the current criterion but would result in SSC more representative of the water body. Figure 1 describes the suggested steps and, in some cases, offers alternatives for states and authorized tribes to consider as they develop their procedure for deriving natural background criteria.

3.1. Part 1 - Determine whether a Natural Background Criterion is Appropriate

There are two questions that should be answered at the outset in order to determine whether a natural background criterion is appropriate: (1) Is the parameter of human origin only? and (2) Is the parameter meeting the applicable WQS or not? (Figure 1). Chemical parameters that are of human origin only are clearly not natural and, therefore, are not eligible for a natural background criterion. This would, therefore, exclude all man-made chemicals.

The second step of part 1 of the process (Figure 1) is dependent on having data and other information that indicate the parameter is either not meeting the applicable WQS or that a more representative SSC is advisable based on the natural condition, regardless of whether the WQS is being met. A record of monitoring data at the site could demonstrate whether the parameter is not meeting a state or tribal WQS and whether a more or less restrictive SSC may be appropriate based on the natural conditions. These observations may occur in the form of approved CWA section 303(d) listings, professional judgment, or repeated trends apparent within a site or region.

If either the parameter of concern (temperature, DO, or pH) is determined to be unnaturally-altered, or available information indicates that a natural background criterion is not appropriate, there would be no change to the criterion for that parameter based on natural conditions (Figure 1).

3.2. PART 2 – DETERMINE WHETHER NONATTAINMENT OF A WATER QUALITY CRITERION IS DUE TO NATURAL PROCESSES

The second part of the process consists of three sequential steps designed to document whether the parameter that is not meeting the WQS documented in Part 1 is due to natural conditions.[3] The three steps (Steps 1-3 of Part 2, Figure 1) are: Step 1: Characterize the site in terms of current and past anthropogenic influences (e.g., altered habitat, land use changes, point and non-point sources); Step 2: Compare site information with selection criteria for defining a natural condition (see below for definition and examples of selection criteria); and Step 3: Determine whether site characteristics meet the selection criteria for natural conditions. If it has been demonstrated that the condition observed is due to natural conditions, then a natural background criterion for that parameter can be pursued in later parts of the process (Figure 1).

The process of characterizing the site should be focused on the selection criteria that are used to define whether the observed parameter variability qualifies as a naturally-occurring phenomenon. The factors that are used to distinguish a natural condition from an anthropogenically-influenced condition are referred to as *selection criteria* in this document. As part of this determination, it is important to document whether the types of human use and development observed in the watershed are generally known to affect the specific water quality parameter(s) of interest.

Selection criteria or factors for deciding whether a given condition represents natural conditions include, but are not limited to:

- The instream and upstream water bodies are surrounded by undisturbed vegetation and natural buffers;
- Historical and current land use within the segment and upstream do not indicate anthropogenic impacts;
- There is insignificant groundwater withdrawal in the area;
- Evidence of hydrological alteration (e.g., dams, impoundments, channelization) is minimal upstream of the site;
- Groundwater recharge to the surface water at the site is not impacted by anthropogenic activities;
- Point source discharges, including wastewater treatment plants and/or industrial discharges, are not present near or upstream of a site;
- Influence of non-point source runoff from agriculture, lawns, golf courses, impervious surfaces, and other human activities is absent in the immediate catchment and upstream; and

[3] This portion of the process is similar to one of the ways available to define reference conditions that the USEPA has previously published (USEPA, 2000a; USEPA 2000b; USEPA 2001).

- Biological measures or indices clearly indicate whether the water body in question has high quality biological integrity, ideally based on state- or region-wide data.

The factors above should be used in combination, as appropriate, for the site and for the parameter of interest to determine whether observed parameter data reflect natural conditions.

Land cover indicating disturbance and potential runoff or discharge includes urban/suburban areas, bare ground, agriculture, mining, and impervious surfaces (Richards et al., 1996; Allan et al., 1997; Johnson et al., 199; Paul and Meyer, 2001; Allan, 2004). Any known point source discharges and major non-point sources influencing the site should be described, noting distance from site and volume/composition of the effluent. Sites in close proximity to NPDES or non-point source discharges or in areas with historical contamination from previous discharges are not appropriate for a natural background criterion. Likely sources of non-point source pollutant loading should be described. To the extent possible, historic land use in the near-field and catchment should also be characterized for these sites, noting anything that could still be a source of legacy contamination or other lingering effects.

In addition to surface water and land cover factors, attention should be given to below ground factors, such as water withdrawals for agriculture, which may alter the salinity, flow, temperature, and DO of surface waters. Degraded water quality due to anthropogenically-impacted groundwater contributions, or altered flows caused by human activities, would not qualify as natural conditions.

Modeling may be one tool, for example, that can simulate the natural condition of the parameter of concern given the physicochemical and biological characteristics of the site, assuming no anthropogenic impacts. Modeling analyses have been used to evaluate natural background criteria for DO and temperature. For example, the EPA has used natural condition water quality modeling in its development of DO TMDLs (USEPA, 2013a), as well as in its development of numeric nutrient criteria for Florida estuaries, including models of DO (USEPA, 2012). However, all modeling assumptions used must be clear and transparent and the model itself should be verified based on peer-reviewed literature or other reputable sources (see Section 3.3 of this document for further discussion).

Another viable option is to demonstrate that a site qualifies for a natural background criterion based on information from known reference (i.e., minimally disturbed) sites in the same region or basin using the reference condition approach (USEPA, 2000a; USEPA 2000b; USEPA 2001). A reference site is a location from which physical, chemical and biological data are accepted as being representative of the ideal reference condition, in this case the proposed “natural condition.”

In determining whether a natural background criterion is appropriate, states and authorized tribes may want to consider the extent to which a site or watershed must be unaffected by anthropogenic activities in order to qualify as a natural level with respect to a given parameter. Watersheds that include limited human activity, such as occasional personal or recreational use, or only minor human development such as hiking trails or a small number of roads and road crossings, may still reflect the natural level for the parameter of concern. Factors that states and authorized tribes could consider in this respect include more quantitative selection criteria such as:

- Agricultural land use at and upstream of the site is less than some threshold percentage identified by the state or tribe as being associated with biologically degraded conditions;
- Urban land use at and upstream of the site is less than some threshold percent identified by the state or tribe as being associated with biologically degraded conditions;
- Road density is less than some fairly low value indicative of sparsely populated areas; and
- Road crossings, bridges, or pipeline crossings are relatively few, or in a sparsely developed area, indicative of a fairly low disturbance rate in the watershed.

To help further identify appropriate selection criteria, it may also be useful to define what would not be considered a natural condition. Some examples are listed below:

- Historic or existing human impacts. Water quality parameter of concern that has been or is currently impacted by industry (e.g., mining, pulp and paper mills, atmospheric deposition), or is substantially impacted by other human activities (e.g., urbanization, agriculture, grazing, timber harvest, etc.).
- Human-caused conditions (or "anthropogenic impacts") from sources outside the watershed, such as atmospheric deposition or ground water aquifers that extend beyond the watershed, determined from GIS or historic documentation.

The site characterization step (Step 1 of Part 2, Figure 1) should present documentation that addresses the selection criteria. This documentation would likely consist of the following as examples:

- GIS maps of the site and its catchment upstream showing land cover/land uses;
- Site reconnaissance survey data regarding presence of roads, channel modifications, outfalls, or other human-made structures that would not be evident from land cover maps;
- Photographs showing extent of riparian vegetation, waterbody size and channel morphology;
- Available records from relevant state or federal agencies indicating no known mining, forestry, or other human activities upstream of the proposed site;
- GIS imagery or photography capturing biological information in historical records that could inform conditions over time;
- Description or inventory of the aquatic life present in the water body as well as any endangered species; and
- Water quality monitoring data for the site.

Once the site characterization has been completed, the results are compared with the selection criteria (Step 2 of Part 2, Figure 1) and a determination is made as to whether the site qualifies for a natural background criterion with respect to the parameter of interest (Step 3 of Part 2, Figure 1). If there are no known anthropogenic influences on the parameter of interest, documentation should still be provided in the form of GIS analyses, contemporary surveys, cultural histories, interviews, and/or similar publicly available or newly generated information.

A finding that the quality of a waterbody reflects the natural condition with respect to the parameter of interest could include:

- An explanation of why human activities in the watershed, if any, are not directly or indirectly the cause of the WQS exceedance for the parameter of interest;
- A documented explanation of how natural processes are adequate to explain the observed non-attainment for the parameter of interest; a conceptual model linking natural conditions to parameter non-attainment could be a useful tool for presenting this documentation;
- A demonstration that conditions in appropriate reference sites indicate that a natural conditions criterion should apply for the parameter of interest in a specific region. (For more information on selecting reference sites see Appendix B.)

In documenting how natural processes explain the observed parameter not meeting the applicable WQS, attention should be given to the following factors described below:

Hydrogeomorphic and physical characteristics

Hydrogeomorphic characteristics include flow regime, channel gradient, and waterbody geomorphology. For systems in which the natural flow regime itself is of interest, other hydrogeomorphic factors may need to be considered, such as groundwater recharge, local climate/precipitation regime, and topography. An example illustrating the importance of hydrogeomorphic characteristics is low DO, which can occur in slow moving, high organic matter coastal plain streams in warmer months (Joyce et al., 1985; Meyer, 1992; Ice and Sugden, 2003). An examination of natural geomorphic factors, such as lack of re-aeration due to the low channel gradient, as well as naturally high biological oxygen demand (BOD) from decomposition of riparian vegetation, should be documented to demonstrate that low DO is not due to eutrophication or other human-caused impacts. A different low gradient, slow moving system may also experience low DO, but nutrient runoff from agriculture or effluent from wastewater treatment plants may contribute to the low oxygen concentration. Thus, it is necessary in this context to not only identify that natural conditions could account for the observations, but also that documented human-induced impacts are not causing or exacerbating those conditions.

In another example, shallow streams may not meet a state's or tribe's temperature standard, at least during the warmest months. An evaluation of natural geomorphology and hydrology of the system can determine whether such temperature non-attainment is natural. Overall, the stream may meet the temperature criterion, but may be in non-attainment in different smaller areas due to placement in the landscape. Such landscape factors can increase or decrease a water body's sensitivity to climatic conditions. When considering flow or hydrology, careful attention should be given to determine whether the observed flows (see the Natural Flow Regime, Poff et al., 1997) are indeed natural. In the Mississippi Delta region, for example, there are concerns regarding drawdown of groundwater due to irrigation, which could cause a loss of base flow, higher water temperatures, and perhaps lower DO (Barlow and Clark, 2011; Barlow and Kroger, 2014). This would not be classified as a natural condition. One other example in this category is natural thermal stratification in lentic or large lotic water bodies resulting in DO concentrations that might be below the DO criterion, at least during certain seasons or flow conditions (Wetze,l 2001; Kalff, 2002).

Land cover, watershed, and biological factors

Factors that influence natural conditions and may contribute to not being able to meet the applicable WQS include: land cover, watershed characteristics, and biological characteristics. For example, in the case of land cover, the natural presence or lack of riparian vegetation may contribute to the waterbody temperature and DO regime (Swanson et al., 1982; Gregory et al., 1991; Naiman and Decamps, 1997). Another example may be frequent inputs of organic matter from riparian vegetation and resultant high bacterial decomposition rates (Meyer, 1990; Meyer and Edwards, 1990; Meyer 1992). This could result in high BOD in summer, resulting in low DO in systems naturally lacking re-aeration mechanisms (Meyer, 1990; Meyer and Edwards, 1990; Meyer, 1992; Ice and Sugden, 2003).

As mentioned previously, one tool that could be used to describe and communicate the natural condition with respect to temperature, DO, or pH is a conceptual model. Similar to the Problem Formulation phase of an ecological risk assessment, a conceptual model depicts the major sources and pathways that are thought (or known) to influence the variability of the parameter of interest. The conceptual model can be a useful communication tool as well as a transparent mechanism to describe the specific characteristics of the natural condition and the available evidence documenting whether the observed non-attainment with a state's or authorized tribe's WQS is due to natural sources, anthropogenic sources, or both. Examples of conceptual models can be found throughout the scientific literature (USEPA, 2008; Cloern, 2001; Bricker et al. 2003).

3.3. PART 3 - DETERMINE THE SPATIAL AND TEMPORAL BOUNDARIES OF THE NATURAL BACKGROUND CRITERION

At the end of Step 3 of Part 2 in the process, a decision is made whether a natural condition causes the parameter's non-attainment and, therefore, whether a site-specific natural background criterion is appropriate. If it is determined that the observed parameter's non-attainment is not the result of natural processes, then a natural background criterion is not appropriate. However, if that is the case a change to the designated use may still be a valid option. In this case a UAA could possibly be conducted and benefit from the information already collected in the previous steps of this framework. If a natural background criterion is an appropriate option, the next step would be to determine the spatial and temporal extent to assess where and when the natural background criterion applies. Parameters influenced by natural conditions are often interrelated (e.g., DO and temperature). Thus, in developing a natural background SSC for a given parameter, other parameters may need to be incorporated in this part of the process.

A study plan should be developed at this point in the process documenting the approach to be used to characterize natural conditions with respect to the parameter of concern and, thereby, the data to be used to calculate the natural background criterion (Step 1 of Part 3, Figure 1). As part of study plan development it is important to describe, either through existing data or through collection of new data, the temporal and spatial characteristics of the parameter. The amount of data will vary with the parameter and the complexity of the site or group of sites. Data aspects to be described should include seasonal or diurnal factors (e.g., flow, precipitation, temperature) influencing the ambient concentrations, as well as other water quality parameters related to the parameter in question (e.g., DO

concentrations are influenced by a variety of factors and fluctuate throughout the day). Also, some parameters will have a critical period (e.g., low flow or warmer temperatures), and sufficient ancillary data should be collected or otherwise be made available to describe such periods. The temporal evaluation may also help determine whether a seasonal criterion may be the most appropriate option (as may be the case for a parameter such as DO, which can be influenced by seasonal flow or temperature changes) and, if so, the timing and duration of alternate seasonal criteria (see Step 5 of Part 3, Figure 1). Review of the Study Plan by the respective EPA Regional Office prior to completing this part of the process is highly encouraged.

Figure 2 shows some suggested options to consider in the study plan development. A conceptual model, as discussed previously under Part 2, may be a useful tool for organizing and communicating the temporal and spatial factors that should be included as part of the study plan and the eventual calculation of the natural background criterion. The level and type of documentation needed to identify the spatial and temporal extent of natural conditions may depend on the natural processes that cause the observed parameter non-attainment, as well as the type of parameter. Documentation of natural conditions ideally would also rely on data from more than one site in the study area and collected over different seasons and years. This is because it may be necessary to capture natural variability in hydrology and other factors that could affect the parameter over time. The type of parameter may also influence the extent of data needed. For example, natural DO varies daily and seasonally as a function of metabolism, temperature, and flow whereas parameters that have less variability may not require the same breadth of data (Allan, 1995). These considerations should be taken into account when designing a study. It is necessary that a sound scientific methodology be used to ensure that adequate data are collected and properly evaluated (e.g., via a quality assurance project plan (QAPP) as part of the Study Plan).

In cases where there might be some anthropogenic activities in the watershed (either past or present), it is useful to include data from known reference sites in the Study Plan, documenting that the reference sites selected are indeed appropriate to the site(s) in question (e.g., in the same class of waterbody and with similar attributes). If appropriate reference sites are not available, it may be necessary to make informed decisions about historical conditions, and/or develop a model to estimate the characteristics of the parameter prior to human influence, to help interpret site data and extrapolate parameter levels in the absence of the anthropogenic sources.

Modeling approaches have been used to understand naturally expected DO dynamics in currently human-impacted water bodies such as Savannah Harbor, Georgia, and the Chesapeake Bay (USEPA, 2010a; USEPA, 2010b). Dissolved Oxygen modeling, as well as paleo-limnological analyses of sediments in the Chesapeake Bay, indicated that deep channels within the Bay naturally experienced low DO conditions prior to human influence (USEPA, 2003). Modeling approaches may be feasible for estimating natural conditions with respect to certain well-studied parameters such as DO or temperature, in which relationships between land cover, waterbody bathymetry, surface water, and sediment are fairly well established and verified for many types of systems. As mentioned previously, states and authorized tribes are highly encouraged to obtain EPA input prior to data collection and analyses, including modeling.

Once the Study Plan has been developed, data and other information specified in the Study Plan are collected and analyzed according to the QAPP (Steps 2 and 3 of Part 3, Figure 1). Data should be collected to present a set of summary statistics describing each parameter and identifying temporal and seasonal trends, as well as critical periods and quality of data being used in the evaluation. The summary data and characteristics should be sufficient for use in developing a natural background criterion for a parameter based either on direct evaluation of the data (from one or more sites that represent the natural condition) or through modeling or other approaches as mentioned above. Given that temperature, DO, and pH can vary considerably in space and time, it may be necessary to collect data that reflect temporal and spatial variability during critical periods (e.g., summer low flow conditions). This information should be used to describe special seasonal or timing considerations for the SSC. Furthermore, this information should be sufficiently robust to support conclusions reached in Parts 1 and 2 of this process demonstrating that observed concentrations or levels of a given parameter are not related to anthropogenic influences and that development of site-specific natural background criteria is appropriate.

Once the data are compiled and summarized, it should be evident as to whether the spatial scale of the natural background criterion is site-specific or relevant to a larger area (e.g., certain class of streams within an ecoregion). In Step 4 of Part 3 (Figure 1) the spatial extent of the SSC is determined. For example, the instantaneous DO criterion is often not met in coastal plain streams in the southeastern U.S. including areas in Mississippi, Alabama, Georgia, Florida and Louisiana. For these larger scale assessments, it may be necessary to include a group of similarly situated sites by river system, water body type (e.g., certain thermally-stratified lakes with episodically low DO), ecoregion, or other physical/geographic conditions, as long as there is a defensible and transparent method for classification. In cases like these, it may be more appropriate to designate a new use or sub-use category (via a use attainability analysis) that properly classifies these water bodies as a group with its own unique water quality characteristics. Once the new use or sub-use is formulated, natural background criteria can then be developed as appropriate using this document so that the new use is protected and maintained.

If the application of the natural background criterion is site-specific, there should also be a determination made as to whether the new criterion applies only to a certain season or time period (Step 5 of Part 3, Figure 1). For example, temperature, DO, and pH may result in non-attainment of WQS only during the summer season in a particular waterbody but attainment of WQS over the remainder of the year. Seasonal flow changes may also affect some parameters.

Depending on the temporal extent and predictability of parameter non-attainment of the state or authorized tribe standard, it may be possible to incorporate additional expressions of a criterion. For example, depending on the daily variability observed in DO concentration under the natural condition, criteria based on weekly or monthly average concentrations, as well as minimum DO natural background concentrations, may be warranted to protect aquatic life uses. Similarly, for systems in which there are naturally large swings in temperature, a daily average value, as well as a maximum value, may be appropriate to protect aquatic life uses. Documenting the overall condition using multiple lines of evidence (e.g., multiple biological assemblages if warranted, as well as land use, hydrological, and

physicochemical information) will often provide the most useful information when deriving a natural background criterion.

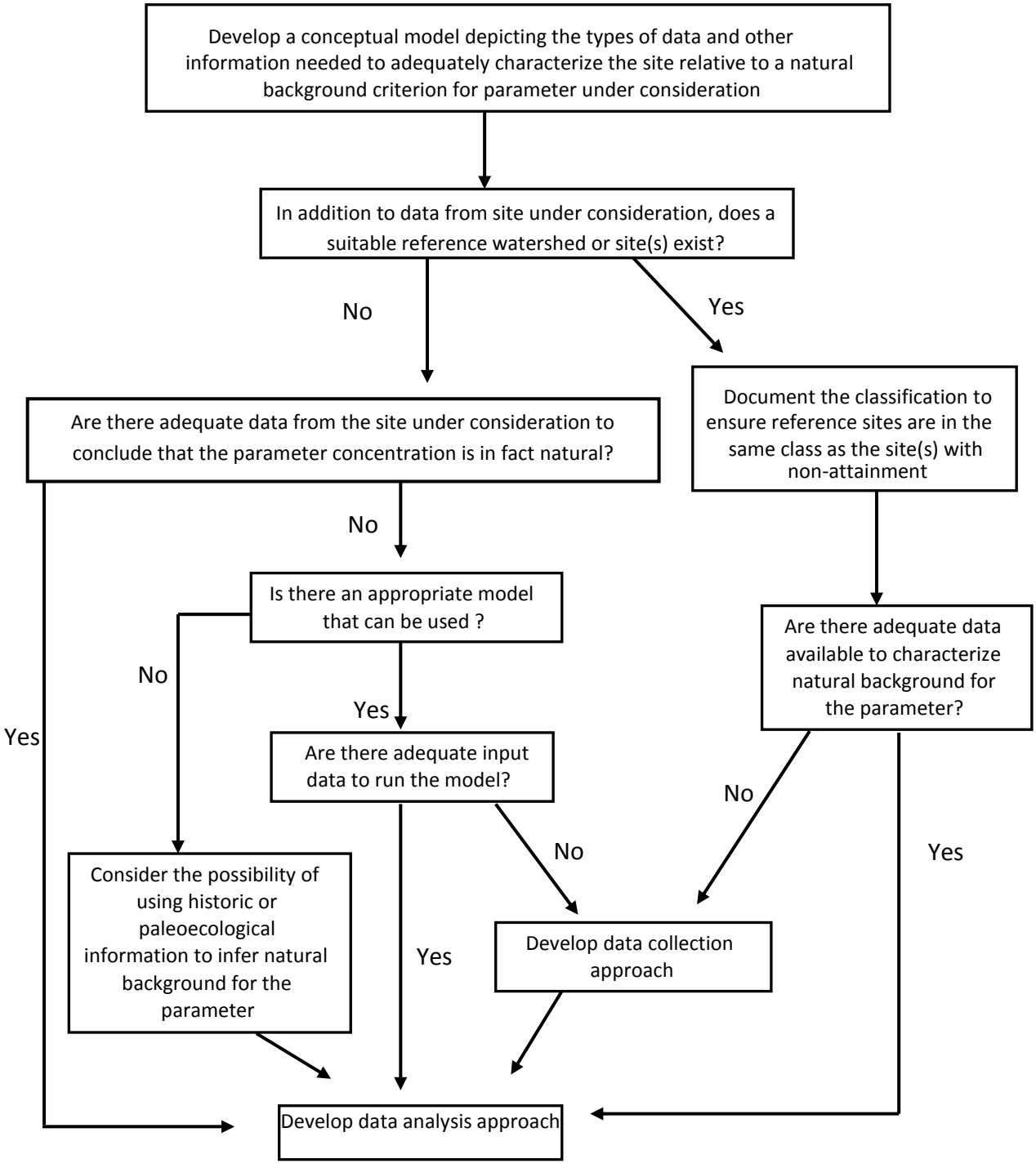

FIGURE 2. CONSIDERATIONS FOR STUDY PLAN DEVELOPMENT AND DEVELOPING THE APPROACH FOR CHARACTERIZING SPATIAL/TEMPORAL BOUNDARIES OF A NATURAL CONDITION STANDARD.

3.4. PART 4 - CALCULATE A NATURAL BACKGROUND CRITERION

Once the basis for a natural condition criterion has been defensibly demonstrated, the last part of the process is to develop the appropriate SSC that protects uses while reflecting the unique natural water chemical/physical conditions. EPA notes that criteria include magnitude, duration, and frequency elements. The general approaches described here are split into empirical statistical approaches (measurement-based) and mechanistic process modeling approaches (modeling-based) to serve as examples. The two approaches may be used separately or in conjunction with one another. In general, an empirical approach uses a statistical model to derive an estimate of the natural condition and a modeling approach relies upon measurements as well as equations that represent key relationships among ecosystem components. (Note – this does not exclude the use of other scientifically defensible approaches).

3.4.1. EMPIRICAL STATISTICAL APPROACH

The basis of an empirical statistical approach is characterizing the natural distribution of values for the parameter(s) of interest and using statistical properties of that distribution to set the SSC. If the site being evaluated has adequate data and has met the set selection criteria, then this approach would be appropriate to set the SSC based on natural conditions. For this approach, long-term data collection using methods and sampling frequencies consistent with the state's data quality objectives, as described in the QAPP, should exist or be initiated. Once completed, the long-term data would be used to calculate daily, monthly, seasonal or annual statistics, depending on the parameter of interest (e.g., average daily DO). Once calculated, the statistical characteristics of these values could be used to develop appropriate criteria. For example, the long-term percentile of annual means associated with the natural condition could be set as the magnitude of the criterion concentration.

If reference sites are deemed necessary to effectively determine the natural condition, then a reference condition approach should be followed (USEPA, 2000a; USEPA, 2000b; USEPA, 2001). An appropriate reference site is a location where the physical, chemical, and biological data are accepted as being representative of the reference condition or in this case, the observed natural condition. A reference site should be demonstrably similar to the natural conditions site and have experienced minimal disturbance from human activities. Data from reference sites can be used to help define the criterion concentration as stated above and can also be used in conjunction with modeling approaches described below.

3.4.2. MECHANISTIC MODELING APPROACH

For applications where human activities may potentially influence conditions but are not expected to influence the parameter of interest, water quality models could be used to inform decision-making both for affirming natural conditions and calculating site-specific natural background criteria. In this option, a water quality model would be used to simulate the water quality parameter of interest under natural conditions, which is then modeled to investigate whether the result is similar to the observed dynamics of the parameter of interest. If so, then the observed parameter dynamics may indeed be the result of natural ecological processes at the site and not anthropogenic influences. For example, a mechanistic

model to examine DO dynamics could be used to quantify the effects of major sources of oxygen-demanding substances. The effects of human sources and natural sources can be quantified, and DO levels resulting from natural sources alone can be determined. This approach could also include information gained from the statistical approaches described above. Different mechanistic modeling approaches exist including watershed loading, hydrodynamic, and water quality models. There are many existing models (USEPA, 2013b), and states and authorized tribes may choose an appropriate modeling structure to use. However, a process should be followed that is sufficient to guarantee model output that can be confidently used to simulate existing and/or natural conditions.

To this end, if mechanistic models are to be used, then, similar to statistical modeling, data quality objectives and measurement quality objectives should be established within a QAPP to assure proper model calibration and validation. These objectives should be developed such that, once they are met, the model output could be used as intended to inform the selection of appropriate natural background criteria.

The EPA's Council on Regulatory Environmental Modeling (CREM) has issued guidance detailing recommendations for the effective use of models in environmental decision making (USEPA, 2009).

3.5. PART 5 – ADOPT NATURAL BACKGROUND CRITERION

As the final step in the natural background SSC development and adoption process, consistent with the requirements of Section 303(c) of the CWA, the SSC must be officially adopted by state or authorized tribal rulemaking into its WQS regulations and reviewed and approved by the EPA before becoming effective for CWA purposes.

The EPA has identified two general approaches states and authorized tribes can use when adopting site-specific water quality criteria: (1) determining a specific outcome (i.e., concentration limit for a pollutant) through the development of an individual numeric criterion, and (2) adopting a criteria derivation process through the performance-based approach.

Developing and adopting SSC into rule has been a more common way to set criteria for natural background compared to the performance-based approach. While derivation of a single site-specific criterion affords flexibility in developing SSC based on each case, it is generally resource-intensive.

A performance-based approach, on the other hand, relies on adoption of a process (i.e., a criterion derivation methodology) rather than a specific outcome (i.e., concentration limit for a pollutant). In a performance-based approach, the state or authorized tribe specifies the procedures it will use to derive SSC (including the methods, minimum data requirements [quality and quantity], and decision thresholds) in its WQS regulation (or legally binding rule-referenced document). When such a performance-based approach is sufficiently detailed and has suitable safeguards to ensure predictable, repeatable outcomes, EPA approval of such an approach serves as approval of the outcomes as well. If a particular state or tribal approach is not sufficiently detailed or lacks appropriate safeguards, then EPA review and approval or disapproval of a specific outcome is still required. Proper construction and implementation of such an approach can result in consistent application of state and tribal narrative water quality criteria and defensible site-specific adjustments to numeric ambient water quality criteria.

4.0 SUMMARY

This framework is provided as one way to assist states and authorized tribes in developing a consistent and transparent procedure for identifying and characterizing natural conditions for the development of SSC for temperature, DO, and pH based on natural conditions for the protection of aquatic life uses. The framework consists of five parts including: 1) Determine whether a natural background water quality criterion is appropriate; 2) Determine whether non-attainment of the water quality criterion is due to natural processes; 3) Determine the spatial and temporal boundaries of the natural background criterion; 4) Calculate a site-specific natural background criterion; and 5) Adopt site-specific natural background criteria. It is highly recommended that states and authorized tribes coordinate early and often throughout the process with the EPA in order to ensure that the appropriate information is used in determining whether a site-specific natural background criterion is appropriate and if so, how the criterion should be expressed.

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APPENDIX A - ESTABLISHING SITE SPECIFIC AQUATIC LIFE CRITERIA EQUAL TO NATURAL BACKGROUND

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

NOV 5 1997

OFFICE OF WATER

MEMORANDUM

SUBJECT: Establishing Site Specific Aquatic Life Criteria Equal to Natural Background

FROM: Tudor T. Davies, Director
Office of Science and Technology

TO: Water Management Division Directors, Regions 1-10
State and Tribal Water Quality Management Program Directors

In the course of reviewing State and Tribal water quality standards (WQS), EPA has identified several issues pertaining to the establishment of site specific numeric criteria on the basis of natural background conditions. EPA is issuing this policy to provide greater clarity and direction for States and Tribes who are considering establishing site specific criteria equal to natural background conditions, and for EPA Regional Offices reviewing State and Tribal water quality management programs.

Background

Site specific criteria are allowed by regulation and are subject to EPA review and approval. The Federal water quality standards regulation at 40 CFR 131.11(b)(1) requires States and authorized Tribes to adopt numeric water quality criteria that are based on section 304(a) criteria, section 304(a) criteria modified to reflect site-specific conditions, or other scientifically defensible methods. Under 40 CFR 131.5(a)(2), EPA reviews State WQS to determine whether a State has adopted criteria to protect the designated uses. Existing guidance and practice are that EPA will approve site specific criteria developed on the basis of sound scientific rationales.

Currently, EPA guidance has specified three procedures for States and Tribes to follow in deriving site specific criteria. These are the Recalculation Procedure, the Water-Effect Ratio Procedure and the Resident Species Procedure. These procedures can be found in the *Water Quality Standards Handbook* (EPA-823-B940005a, 1994). EPA also recognizes there may be naturally occurring concentrations of pollutants which may exceed the national criteria published under section 304(a) of the Clean Water Act.

Policy

This policy applies only to site specific numeric aquatic life criteria based on natural background. States and Tribes may establish site specific numeric aquatic life water quality criteria by setting the criteria value equal to *natural* background. Natural background is defined as background concentration due *only* to non-anthropogenic sources, i.e., non-manmade sources. In setting criteria equal to natural background the State or Tribe should, at a minimum, include in their water quality standards:

(1) a definition of natural background consistent with the above;
(2) a provision that site specific criteria may be set equal to natural background;
(3) a procedure for determining natural background, or alternatively, a reference in their water quality standards to another document describing the binding procedure that will be used.

Discussion

A State or Tribal procedure for determining natural background will need to be specific enough to establish natural background concentration accurately and reproducibly. States and Tribes should also provide for public notice and comment on the definition, the provision, the procedure and the site specific numeric criteria derived from the procedure. The State or Tribe will need to document the resulting site specific numeric criteria in the State or Tribal water quality standards, including specifying the water body segment to which the site specific criteria apply. This can be accomplished through adopting the site specific criteria into the State or Tribal WQS, or, alternatively, by appending the site specific criteria to the WQS. In either case, the State or Tribe must comply with the public participation requirements of 40 CFR 131.20 and 40 CFR Part 25, and State and Tribal citizens should be able to readily determine the water quality criteria applicable to specific water bodies.

For aquatic life uses, where the natural background concentration for a specific parameter is documented, by definition that concentration is sufficient to support the level of aquatic life expected to occur naturally at the site absent any interference by humans. The State or Tribe should consider refining the designated use for the water body to more precisely define the existing aquatic life use.

This policy does not apply to human health uses. For human health uses, where the natural background concentration is documented, this new information should result in, at a minimum, a re-evaluation of the human health use designation. Where the new background information documents that the natural background concentration does not support a human health use previously believed attained, it may be prudent for the State or Tribe to change the human health use to one the natural background concentration will support (e.g., from drinking water supply to drinking water supply only after treatment).

Conclusion

This policy explains and clarifies the use of natural background conditions in establishing site specific criteria for protection of aquatic life uses. In addition to the three procedures listed above for deriving site specific criteria as discussed above, States and Tribes can address natural background conditions through refining the designated use to more accurately reflect the aquatic community present within the stream segment. EPA recognizes that there are other options available to States/Tribes to account for other ambient conditions (e.g., concentrations due to non-natural, man-made conditions) which exceed the national criteria. One such option is for a State or Tribe to conduct a Use Attainability Analysis, consistent with the requirements of 40 CFR 131.10, and adopt a use which is less than the 101(a) goal uses of the Clean Water Act, e.g., less than "fishable/swimmable", or modify a 101(a) goal use such that less stringent criteria are required. In any case, the existing uses of the water body segment must be maintained and protected.

If you have any questions or concerns regarding this policy, please contact me or have your staff contact Elizabeth Southerland, Acting Director, Standards and Applied Science Division, at 202-260-3966.

cc: Lepow, OGC
Wayland, OWOW
Cook, OWM
Dougherty, OGWDW

APPENDIX B - REFERENCE SITE SELECTION - EPA REGION 10 NATURAL CONDITIONS WORKGROUP REPORT ON PRINCIPLES TO CONSIDER WHEN REVIEWING AND USING NATURAL CONDITIONS PROVISIONS, PAGES 22-28

Excerpts from *EPA Region 10 Natural Conditions Workgroup Report on Principles to Consider When Reviewing and Using Natural Conditions Provisions*

Reference Condition

An ideal reference condition describes the physical, chemical, and biological characteristics of a water body in the absence of any human disturbance and pollution. It is important to distinguish between a reference condition and a reference site. A reference site is an actual location from which physical, chemical and biological data are accepted as being representative of the ideal reference condition. A reference location may be appropriate for a particular parameter or project but may not represent a reference condition for all parameters or projects.

Using Data from Reference Locations

When comparing data from a potentially impaired assessment site to a reference condition, the selection of an appropriate reference site is a critical aspect of the analysis. In order to be an acceptable location, a reference site should be demonstrably similar and relatively undisturbed by human activities. The reference site should be similar to the impaired site in its essential chemical, physical and biological characteristics. For use in a natural conditions determination, a reference site needs to have experienced minimal disturbance from human activities and should have a similar natural disturbance regime to that expected in the assessment watershed.

Recommendations for Documenting the Appropriateness of a Reference Site

When documenting the appropriateness of a reference site to make a natural condition determination at an assessment location, we recommend providing the following information:

- Demonstrate that the proposed reference location and the assessment location are comparable (see Appendix E for definitions of the various types of reference conditions).
- Document the similarity between the locations on the basis of the following: geographic proximity, elevation, climate, watershed size, timing and quantity of flow and other factors relevant to the parameter of concern, such as erosion potential.
- Describe the extent and degree of human impacts as quantitatively as possible
- Describe the amount of natural disturbance as quantitatively as possible
- Explain the relationship between the disturbances and the parameter of concern
- Demonstrate that the proposed reference watershed has been minimally affected by human activities, and that the level of natural disturbance is comparable to what would be expected in the assessment watershed in the absence of human activity.
- Demonstrate that the existing level of disturbance would not be expected to significantly impact the parameter of concern.