APPENDIX C

NUTRIENT LISTING METHODOLOGY FOR PERENNIAL STREAMS AND RIVERS

NEW MEXICO ENVIRONMENT DEPARTMENT
SURFACE WATER QUALITY BUREAU

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Purpose and Applicability

This document establishes a listing methodology for determining impairment due to excessive nutrients in perennial streams and selected river segments. This assessment is only applied to perennial streams and selected river segments at this time because the research used to develop this listing methodology is based upon data and information collected from these waterbody types.

This protocol was developed to support interpretation of the *State of New Mexico Standards for Interstate and Intrastate Surface Waters* narrative standard for nutrients found at 20.6.4.13 NMAC (https://www.env.nm.gov/swqb/Standards/):

> ***E. Plant Nutrients:*** *Plant nutrients from other than natural causes shall not be present in concentrations which will produce undesirable aquatic life or result in a dominance of nuisance species in surface waters of the state.*

Nutrients are essential for proper functioning of ecosystems. However, excess amounts of nitrogen and phosphorus can cause undesirable aquatic life (e.g., community composition shifts or toxic algal blooms) and/or result in a dominance of nuisance species (e.g., excessive and/or unsightly algal mats, both attached and detached, or surface algal scums). Unfortunately, the magnitude of nutrient concentration that constitutes "excess" is difficult to determine because natural nutrient concentrations vary widely and interact with many biological and physical variables. Nutrient pollution results in a continuum of undesirable effects depending on numerous factors. For example, nutrient concentrations that would not cause a problem in rapidly flowing, well-shaded headwater streams can create major algae blooms in lower gradient, slow moving streams and rivers with little or no forest canopy.

In 2015 and 2016, the Surface Water Quality Bureau (SWQB) collaborated with Tetra Tech, Inc., the United States Environmental Protection Agency (EPA)Region 6, and EPA's National Nutrient Criteria Program Nutrient Scientific Technical Exchange Partnership and Support (N-STEPS) program on a project to revise nutrient impairment thresholds in New Mexico. This project follows EPA's nutrient criteria guidance (EPA 2010) and Empirical Approaches for Nutrient Criteria Derivation (EPA 2009). Statistical analyses of available state and regional data were conducted to refine nutrient thresholds using defined reference conditions, relationships between cause and response variables and a verified classification system. The resultant candidate thresholds were evaluated by SWQB staff, and the selected thresholds were used to revise this nutrient listing methodology.

The 100+ page report (Jessup et al. 2015) detailing the N-STEPS effort is available at http://www.nmenv.state.nm.us/swqb/Nutrients/. The SWQB also generated and posted a shorter document which summarizes the steps taken to determine the candidate thresholds, and SWQB's logic regarding final threshold selection (NMED/SWQB 2016).

Exclusions

This methodology is not applicable to the following water body types because 1) the necessary research and implementation procedures have either not been investigated by the SWQB or are not yet developed, or 2) a methodology specific to the water body type resides elsewhere:

- Lakes or reservoirs
- Select large rivers (low gradient, non-wadeable)
- Intermittent streams which includes water bodies under 20.6.4.98, 20.6.4.128, or 20.6.4.136 NMAC
- Ephemeral streams which includes water bodies under 20.6.4.97, 20.6.4.128, or 20.6.4.137 NMAC

- Wetlands or playas

In a semi-arid hydrologic setting such as New Mexico, some perennial streams naturally have very shallow or low flow. If this flow setting is truly natural (i.e., there are no upstream diversions, etc.), consideration of the influence of extreme low flow and resultant higher water temperature or higher amount of organic matter on nutrient levels and dynamics should be considered to determine if the below nutrient thresholds are applicable on a case-by-case basis. Similarly, site-specific approaches to determining nutrient impairment may be warranted in effluent-dominated systems based on the specific receiving water's ability to ever achieve reference or near reference condition. In addition, the hydrology protocol[1] should be performed prior to completing a nutrient assessment to confirm a stream reach is perennial when it is unclear.
A separate nutrient listing methodology for lakes and reservoirs (Appendix D of the Listing Methodologies) is available at: https://www.env.nm.gov/surface-water-quality/calm/. Additional information on nutrient threshold development is available on the SWQB's website at: https://www.env.nm.gov/surface-water-quality/nutrients/.

The SWQB typically distinguishes rivers from streams for monitoring and assessment purposes by defining systems that cannot be monitored effectively with the biological and habitat methods developed for wadeable streams. These rivers also generally meet the Simon and Lyons (1995) definition of great rivers as those having drainage areas greater than 2,300 square miles (mi2), although there are many systems is in New Mexico that meet this definition but are suitable for wadeable stream monitoring and assessment methods due to the arid nature of the region and subsequent channel characteristics. For nutrient assessment purposes, the below systems are exempt from this protocol (additional data collection and analysis are on-going to propose thresholds for these river reaches in subsequent listing methodologies):

1. San Juan River from the Navajo Nation to Navajo Reservoir,
2. Rio Grande in New Mexico,
3. Pecos River from the Texas border to Sumner Reservoir,
4. Rio Chama from the Rio Grande to El Vado Reservoir (due to flow augmentation from the San Juan/Chama project),
5. Canadian River from the Texas border to the Cimarron River, and
6. Gila River from the Arizona border to Mogollon Creek.

1.0 Introduction

Nutrient pollution can be described as excess amounts of nitrogen and phosphorus and the resultant high algal biomass. Nutrient impairment occurs when algae and other aquatic vegetation (macrophytes) interfere with designated uses such as domestic water supply or aquatic life. Algal blooms can produce toxins harmful to human and animal uses, and can also cause taste and odor problems in drinking water supplies. One of the most expensive problems caused by nutrient enrichment is increased treatment required for drinking water.

The variables referred to in this document are measurable water quality parameters that can be used to evaluate the degree of eutrophication in perennial streams and applicable rivers. Eutrophication is the process by which a body of water becomes enriched with nutrients that stimulate the growth of aquatic plant life. During the day, aquatic vegetation produce oxygen, sometimes leading to supersaturation. At night, however, excessive algal growth can deplete dissolved oxygen (DO) in the waterbody through respiration and decay of dead algal cells and other organic matter. Low DO concentrations and increased diel fluctuations can cause shifts in community composition and in severe cases, the death of other organisms such as macroinvertebrates and fish. Eutrophication can be a natural incremental process for a water body, but human activities may greatly enhance the process to the detriment of aquatic life (Art 1993).

[1] https://www.env.nm.gov/surface-water-quality/hp/

Enrichment from excess nutrient levels in streams may lead to loss of diversity and native taxa; changes in algae, aquatic plant, invertebrate, and fish community structure; and subsequent loss of ecosystem function. Nutrient enrichment can also lead to excessive phytoplankton growth that can reduce light penetration and consequently limit the growth of submerged aquatic plants in slow moving waters, decreasing available habitat and shelter for certain fish and their prey (Sand-Jensen et al. 2000). A direct effect of nutrient enrichment in streams can be a dominance of nuisance filamentous benthic algae during the peak summer growing season, which can alter the flow environment and negatively impact the physical benthic habitat used by both stream invertebrates and vertebrate organisms (Welch et al. 1989, Chessman et al. 1992) and cause a subsequent shift in community composition towards less desirable aquatic life compared to natural conditions. For example, excessive nutrients can lead to shifts in the dominant benthic macroinvertebrate community composition from more pollution sensitive species such as mayflies, stoneflies, and caddisflies to more pollution tolerant (and less desirable) species such as aquatic worms, midge fly larvae, and pouch snails (Sabater et al. 2005; Miltner and Rankin 1998).

Nutrient enrichment results in excessive growth of primary producers as well as certain heterotrophic microorganisms, which increases the metabolic activities of surface waters and can lead to a depletion of DO (Mallin et al. 2006). Because algal biomass above nuisance levels often produces large diel fluctuations in DO concentration (daily delta DO), caused by high maximum rates of productivity (Pmax) and respiration (Rmax), these response variables are often used as indicators of nuisance levels of algal biomass. While nutrient enrichment may benefit the growth and reproduction of certain fish species in the short term, the ecological consequence of excessive nutrients can have detrimental impacts on stream ecosystems, especially through the reduction in DO levels which would exclude or reduce more sensitive taxa (Stockner et al. 2000). In addition, excess algae growth could reduce or eliminate critical food sources and protective habitat, further impacting survivorship of sensitive species such as trout.

2.0 Nutrient Scientific Technical Exchange Partnership & Support (N-STEPS) Project Summary

Narrative criteria should be translated to numeric thresholds to develop consistent impairment determination protocols. Revision of thresholds and the associated listing methodology was needed to better define nutrients from “other than natural causes,” and link nutrient concentrations with the impairment of designated uses.

The N-STEPS analysis consisted of two major approaches: reference conditions and stressor-response relationships. The reference condition approach derived candidate thresholds from distributions of nutrient concentrations from least disturbed sites which are the best estimate of “natural” conditions. Stressor-response analyses derived candidate thresholds by defining the relationships between total nitrogen (TN) or total phosphorus (TP) concentrations (i.e., causal variables) and response variables and determining the level of the causal variable that corresponds to a change in the response variable.

Diatom and benthic macroinvertebrate metrics, DO, and chlorophyll *a* (chl-a) concentrations were among the response variables explored in the N-STEPS analysis. Response variables represent the relative integrity of the aquatic community and indicate when designated aquatic life uses are protected, thereby prohibiting “undesirable aquatic life” or “dominance of nuisance species.” DO is an applicable, indirect response variable and was used as a surrogate for nuisance algae because increases in algae biomass lead to increases in benthic chl-a concentrations which are correlated with several DO metrics, specifically minimum daily DO, daily change in DO (delta DO), and Pmax. Daily delta DO is defined as the difference between the maximum and minimum DO concentration within a 24-hour period. In the N-STEPS analysis, all three of these DO metrics were correlated to each other as well as to chl-a concentrations and a variety of benthic macroinvertebrate indices.

The steps used to identify nutrient thresholds for perennial streams and rivers in New Mexico included:

1. Selecting and evaluating data
2. Defining the human disturbance gradient
3. Forming site classes
4. Developing frequency distributions of least disturbed sites
5. Evaluating estimated stressor–response relationships
6. Synthesizing multiple thresholds (and identifying the most appropriate for NM waters)

These steps are based on the EPA guidance for developing numeric nutrient thresholds and criteria (EPA 2009, 2010). The details of each step are available in summary form or in entirety in separate documents available on the SWQB web site (NMED/SWQB 2016 and Jessup et al. 2015, respectively): http://www.nmenv.state.nm.us/swqb/Nutrients/.

Data were collected between 1990 and 2012 within New Mexico and the same ecoregions in surrounding states through SWQB and national monitoring programs, including the National Rivers and Streams Assessment (NRSA), the Wadeable Streams Assessment (WSA), and Environmental Monitoring and Assessment Program (EMAP). A geographic information system (GIS) analysis of sites and their catchments was conducted to characterize environmental conditions for use in disturbance gradient designations and site classification.

The reference site and human disturbance gradient analysis of 542 sites resulted in 31% of sites being identified as least disturbed (i.e., reference or near reference) sites. Analyses of least disturbed sites were used to determine site classes based on nutrient conditions and landscape classification variables such as geology, land slope and ecoregion. For nitrogen, concentrations were associated with average catchment (i.e., watershed) land slope, and three TN classes were identified as TN Flat, TN Moderate, and TN Steep (Table 1, Figure 1).

Table 1. Site classes for TN

Site Class	Description
TN Flat	Sites with average catchment land slopes less than <15%
TN Moderate	Sites with average catchment land slopes from 15% to 32%
TN Steep	Sites with average catchment land slopes > 32%

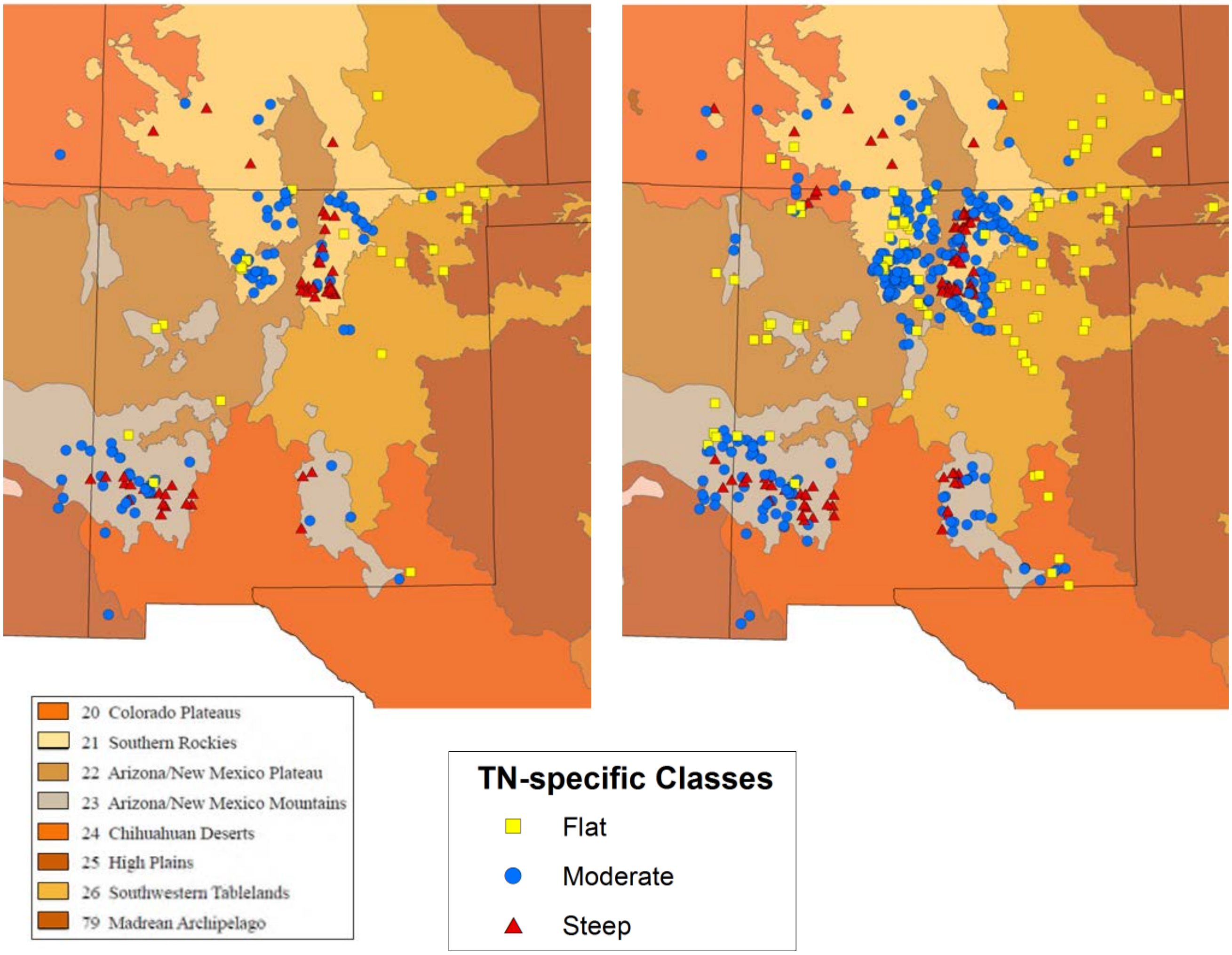

Figure 1. Least disturbed sites (left) and all sites (right) by the TN-specific site classes (from Jessup et al. 2015).

For phosphorus, the concentration of TP in soil and volcanic geology were important in addition to average catchment land slope, resulting in three different nutrient classes identified as TP High-Volcanic, TP Flat-Moderate, and TP Steep (Table 2, Figure 2).

Table 2. Site classes for TP (and delta DO)

Site Class	Description
TP High-Volcanic	All sites in the Jemez, Conejos, Upper Gila, Upper Gila-Mangas, San Francisco, and Mimbres watersheds (HUCs 13020202, 13010005, 15040001, 15040002, 15040004, and 13030202, respectively). In the Upper Gila watershed, it excludes sites in the Diamond, Taylor and Beaver Creek sub-watersheds (HUCs 150400010404, 150400010406, 150400010402, 150400010403, 150400010305, and 150400010302).
TP Flat-Moderate	Sites with average catchment land slopes ≤ 29% average land slope that are not in the TP High-Volcanic site class.
TP Steep	Sites with average catchment land slopes > 29% that are not in the TP High-Volcanic site class.

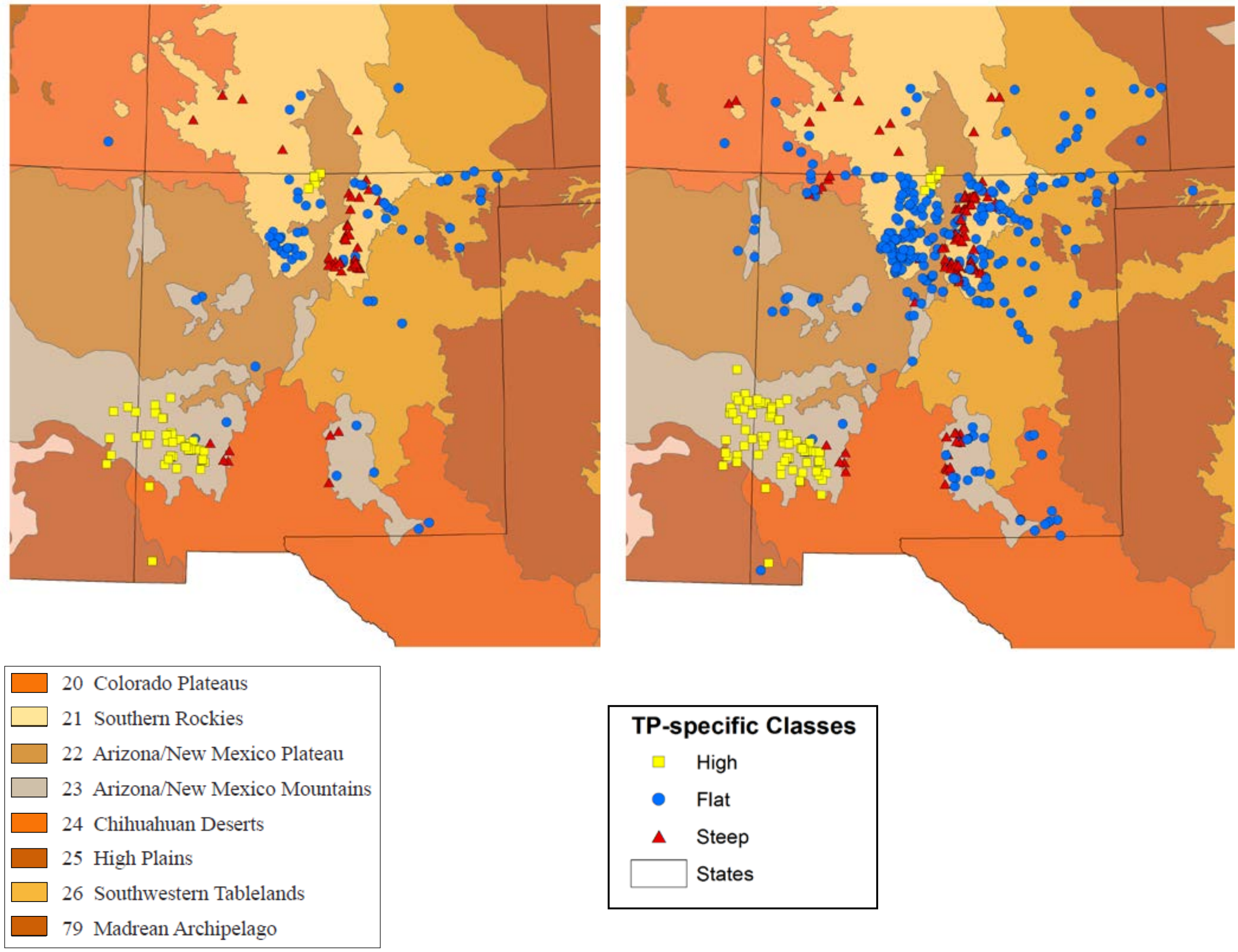

Figure 2. Least disturbed sites (left) and all sites (right) by the TP-specific site classes (from Jessup et al. 2015). Sites noted as "Flat" in the legend include the entire TP Flat-Moderate class.

Frequency distributions of nutrient conditions (defined as the median site value in Jessup et. al 2015) in least disturbed sites were used to derive TN and TP candidate thresholds for each site class. Correlation and other multivariate techniques supported the major linkages between nutrient concentrations, chl-a, delta DO, diatoms, and macroinvertebrates. Although chl-a relationships supported some causal linkages between nutrients and DO, the relationships between nutrient concentration and chl-a were too weak and inconsistent to support its use as indicator of nutrient impairment (Jessup et al. 2015). Multiple regression interpolations and change-point analyses for macroinvertebrates, diatoms, and delta DO in response to nutrient concentrations resulted in multiple candidate TN and TP thresholds in each site class.

For each site class combination, candidate thresholds were evaluated against stressor-response analyses to select the impairment thresholds shown in Tables 3 and 4. NMED chose the 90th quantile to represent a starting point for candidate thresholds. Ultimate quantile selection for threshold development is dependent upon the data used to develop the quantiles, the confidence that these data accurately reflect reference condition, and the best alignment of the quantile with the benthic macroinvertebrate and diatom change point analyses to provide assumed protection of the applicable designated aquatic life use(s). Selecting a quantile in the upper boundary of the reference population provides confidence that the threshold adequately represents an impaired condition to the listing methodology. During initial threshold selection and earlier versions of this listing methodology, the 85th, 80th, the 75th quantiles were selected for site classes TN Flat, TN Moderate, and TP High-Volcanic, respectively, rather than the 90th quantile in order to move the proposed threshold closer to the tendency of all candidate thresholds (see NMED/SWQB 2016 for additional detail on threshold selection). Upon further consideration, the 90th quantile will be used for these site classes in recognition of the challenge of reducing nutrients to the lower quantile thresholds in streams with naturally high nutrients, as suggested by the high reference-derived thresholds in site classes (Jessup et. al 2015). Also, the N-STEPS project used site medians vs. individual TN and TP data values in the analyses (Jessup et. al 2015). Comparing site medians rather than individual sampling events to numeric thresholds is also better aligned with the intention of identifying chronic excessive nutrients conditions. The TN and TP site median upper assessment threshold, defined as the 90% confidence interval (CI) of the 90th quantile by site class (i.e., the very upper limit of the quantile analysis), are also included in Table 3 and used in this protocol as detailed in Section 3.0. The selected daily delta DO response thresholds in Table 4 will be applied by TP site class because daily delta DO was significantly correlated with TP; therefore, TP site classes were used to determine appropriate delta DO thresholds (Jessup et al. 2015).

Table 3. TN and TP causal thresholds by site class

Parameter and Site Class	Site Median Threshold (90th quantile) (mg/L)	Site Median Upper Assessment Threshold (90% confidence interval of 90th quantile) (mg/L)
TN Flat	0.69	0.85
TN Moderate	0.42	0.51
TN Steep	0.30	0.34
TP High-Volcanic	0.105	0.114
TP Flat-Moderate	0.061	0.069
TP Steep	0.030	0.053

Table 4. DO response thresholds by site class

Site Class	Daily Delta DO* Threshold (mg/L)
TP High-Volcanic	5.02
TP Flat-Moderate	4.08
TP Steep	1.79

NOTES: *The daily delta DO threshold is defined as the difference between the maximum and minimum DO concentration within a 24-hour period.

3.0 Assessment Data

Nutrient and DO long-term data are collected during regular SWQB watershed surveys following the SWQB's Standard Operating Procedures (SOPs) (http://www.nmenv.state.nm.us/swqb/SOP/).
Algal biomass above nuisance levels often produces large diel fluctuations in DO. Accordingly, diel DO data are collected using continuous recording devices (sondes or DO data loggers) to observe diel fluctuations as opposed to the "snapshot" that grab data provide. After all data are received from the lab or field staff, validated/verified, and upload to SWQB's in-house database (SQUID), nutrient and DO data are downloaded

via a series of SQUID assessment reports. TN and TP site classes will be determined with assistance from NMED's IT Department and stored in SQUID.

3.1 Long-term dissolved oxygen data

Sonde deployments are preferably done during the respective growing season. Assessments of delta DO are made with a minimum of 72 hours of sonde or DO logger data, collected during the growing season (Table 5), with a maximum interval of one hour between data points. The SWQB typically deploys sondes or DO loggers for three to fourteen days to record at least hourly DO values. For SWQB collected data, additional information regarding the preferred timing of sonde deployment is typically provided in applicable Field Sampling Plans or Water Quality Survey Reports (available at: https://www.env.nm.gov/surface-water-quality/water-quality-monitoring/).

Table 5. Growing seasons for New Mexico ecoregions and elevations

Site Class	Level 3 Omernick Ecoregion	Growing Season
Mountain >7500 ft	22 & 23	July 1-Oct 15
Mountains <7500 ft & Plateau	20, 21, 22 & 23	Jun 15-Nov 1
Southern Deserts and Plains	24, 25, 26, & 79	May 15-Nov 15

3.2 Total nitrogen and total phosphorus data

There is no numeric criteria or definition of "total nitrogen" in 20.6.4 NMAC. An approved definition for total nitrogen (TN) is not listed in 40 C.F.R. Part 136 but is usually taken to mean the sum of Total Kjeldahl Nitrogen (TKN) and Nitrate+Nitrite (NO3+NO2). Therefore, the SWQB determines "TN Calculated" as the sum of NO3+NO2 and TKN for nutrient assessments. If either TKN or NO3+NO2 is unavailable for a particular sampling event, TN Calculated is noted as a "missing data point" with respect to this listing methodology.

The TKN and NO3+NO2 detection limits, referred to as minimum reported limits [MRL] in SQUID, are added together to determine the "TN Calculated MRL." For this listing methodology, the following terms related to analytical method sensitivity may be synonymous and will be evaluated on a case-by-case basis depending on the particular analytical lab because reporting practices vary: "quantitation limit," "reporting limit," "level of quantitation," and "minimum level." If either TKN or NO3+NO2 are reported as below the MRL, the respective MRL value is used to determine the TN Calculated value for the assessment dataset. If both TKN and NO3+NO2 are reported as below the MRL, the resultant TN Calculated value is noted as "below the MRL." Figure 3 details how to determine whether or not available TN Calculated data can be used for assessment based on the relationship between the MRLs and the applicable TN threshold. The respective TP and TN data MRLs for a particular sampling event must be equal to or less than the threshold in order to be useful for assessment.

Since the MRL reported by the SWQB's most frequently used laboratory (the State Laboratory Division or SLD) for EPA Method 351.2 (TKN) was greater than the TN Moderate and TN Steep thresholds prior to 2017, the SWQB had a subset of samples analyzed for TN using the persulfate digestion method (TPN, Method 4500-N.C in APHA et al. 2018). TPN has a MRL of 0.01 mg/L which is well below these TN thresholds. Regular analyses by the TPN method by an out-of-state contract lab are not sustainable into the future due to financial constraints, and SLD does not offer this method. The SWQB held a series of meetings with SLD to resolve detection limit concerns. SLD is actively working to reduce both TKN and NO3+NO2 MRLs. In the interim, SLD has agreed to provide J-flagged (i.e., estimated data greater method detection limit [MDL] but less than the MRL) TKN and NO3+NO2 data to the SWQB for consideration. Concurrent TPN data per method 4500-N.C and TN Calculated data from SLD (a subset of which are J-flagged because one or both components were J-flagged) collected during SWQB's 2017-2018 survey years were compared. Based on this review and because TN is an additive value, the SWQB has determined that it is permissible to use J-flagged SLD data for nutrient assessments[2].

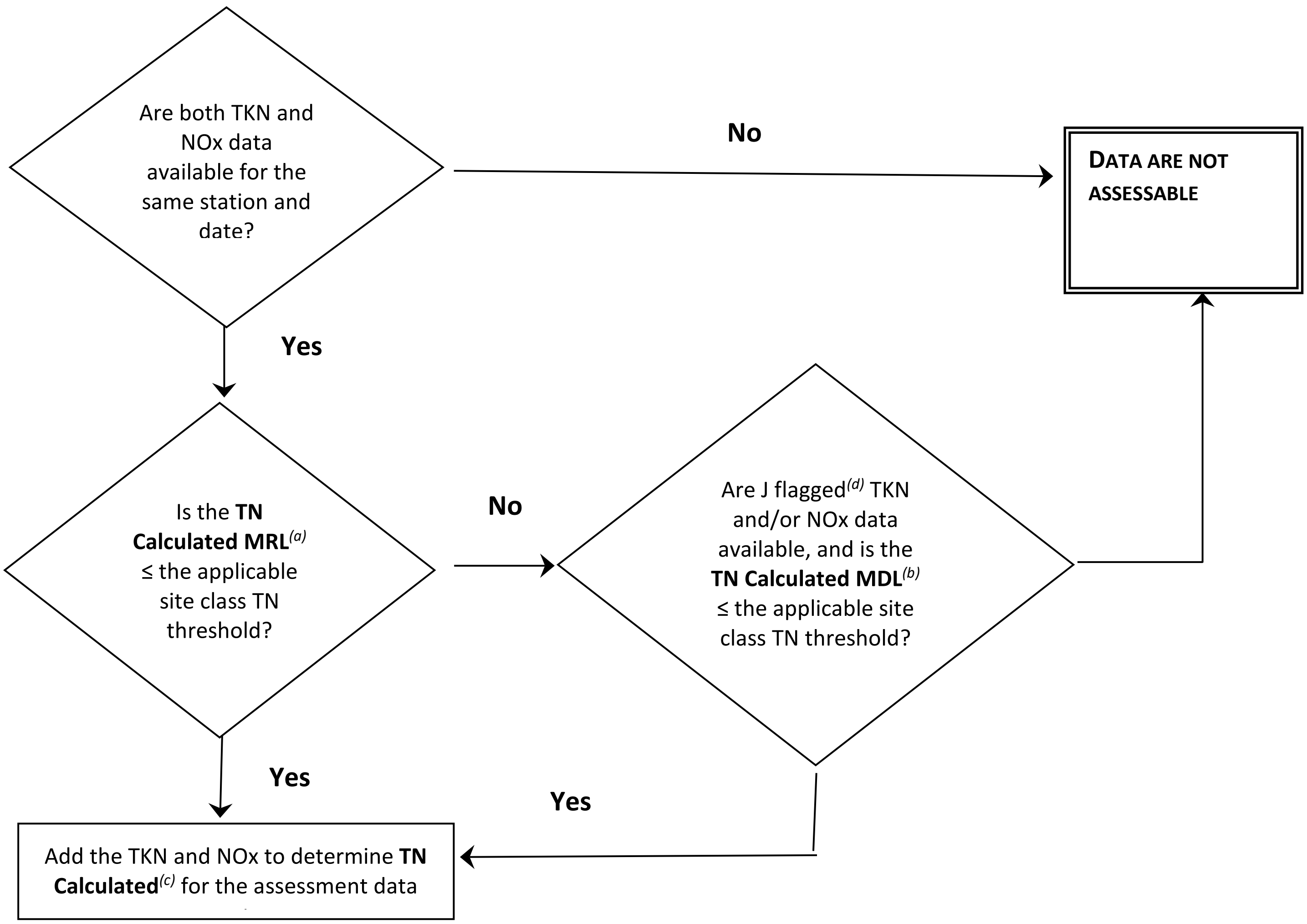

Figure 3. Generalized flowchart for calculating and determining **TN Calculated** and data usability

NOTES: Total Kjeldahl Nitrogen = TKN; Nitrate+Nitrite = NO3+NO2 = NOx; Method Reporting Limit = MRL; Method Detection Limit = MDL

[(a)] TN Calculated MRL = the TKN MRL + the NO3+NO2 MRL

[(b)] TN Calculated MDL = the TKN MDL + the NO3+NO2 MDL

[(c)] TN Calculated = TKN + NOx. For either, use the MRL if reported as non-detect.

[(d)] J flagged = Value between MRL and MDL

[2] A summary of the data comparison is available at: https://www.env.nm.gov/surface-water-quality/nutrients/.

If concurrent TPN and TN Calculated data are available, assessable, and detected above their respective MRLs, the higher value will be used. If concurrent data are assessable and TN Calculated is at the MRL, the TPN value will be used.

4.0 Assessment Procedure

To determine if there is nutrient impairment in a stream reach, two levels of assessment are performed in sequential order (Figure 4). The first step considers causal indicators alone (TN and TP), and the second step considers a response indicator if the TN or TP causal thresholds are exceeded but the respective upper 90% confidence interval are not.

TN, TP, and DO concentrations and variability can all be influenced by storm events. Outliers were removed from the respective datasets prior to threshold development (Jessup et. al 2015). The developed thresholds are intended to assess an on-going condition of excessive nutrients vs. spikes in concentrations or DO swings as a result of isolated weather events. Accordingly, potential outliers will be identified during the assessment process. For nutrient assessments, statistical outliers are defined as TN, TP, or delta DO values greater than the 75th percentile (Q3) of the respective value plus three times the inter-quartile range (IQR). The IQR is defined as the difference between the 25th percentile (Q1) and Q3 (Tukey 1977, Seo 2006). This approach is intended to 1) reduce the influence from autocorrelation of continuous DO data, 2) demonstrate the repeatability of an observation, and 3) take into consideration potential anomalies in the data set due to extreme deviations from seasonal norms, other anomalous events such as runoff from catastrophic fire areas, or instrument errors. TN and TP site medians are first compared to the applicable upper assessment thresholds shown in Table 3 as described in the assessment flowchart (Figure 4) and Table 6. If enrichment is indicated, the assessor determines if there is a response in either the assessed Assessment Unit (AU) or downstream by comparing available daily delta DO data to the applicable threshold in Table 4 per Figure 4 and Table 7.

If a delta DO response is documented, the AU is noted as **Not Supporting** for nutrients. If not, it is noted as **Fully Supporting** (prioritized for additional sampling as resources allow) because the high nutrients do not appear to be resulting in either a local or downstream effect. This first step of screening for high nutrient values at the upper boundary of the threshold and considering downstream AU responses is necessary because the displacement of effects from excessive nutrient input is a common and challenging problem with nutrient impairment determinations. For example, excessive point or non-point nutrient inputs that result in TN or TP levels well above their respective thresholds in an upstream AU may not result in excessive algal growth and concurrent DO impacts in that particular stream reach due to substrate type or shading (e.g., a sandy stream bed that is not conducive to algal growth). In these cases, a downstream stream reach with a more conducive substrate or exposure can experience excessive vegetative growth that will take up the nutrients and result in low in-stream TN and TP values. A goal of the nutrient listing methodology is to correctly identify the AU where the nutrient input(s) are occurring in order to address this displacement effect. Potential displacement effects may be further explored during subsequent total maximum daily load (TMDL) development.

If an upper threshold is not exceeded, TN and TP are then compared to the applicable thresholds in Table 3 per Figure 4 and Table 6. If enrichment is not indicated for TN or TP, the AU is noted as **Fully Supporting** for nutrients. If enrichment is indicated for TN or TP, available daily delta DO data are compared to the applicable threshold per Figure 4 and Table 7. If a response is not indicated by the daily delta DO, the AU is noted as **Fully Supporting** for nutrients; however, if a response is indicated, the AU is noted as **Not Supporting** for nutrients.

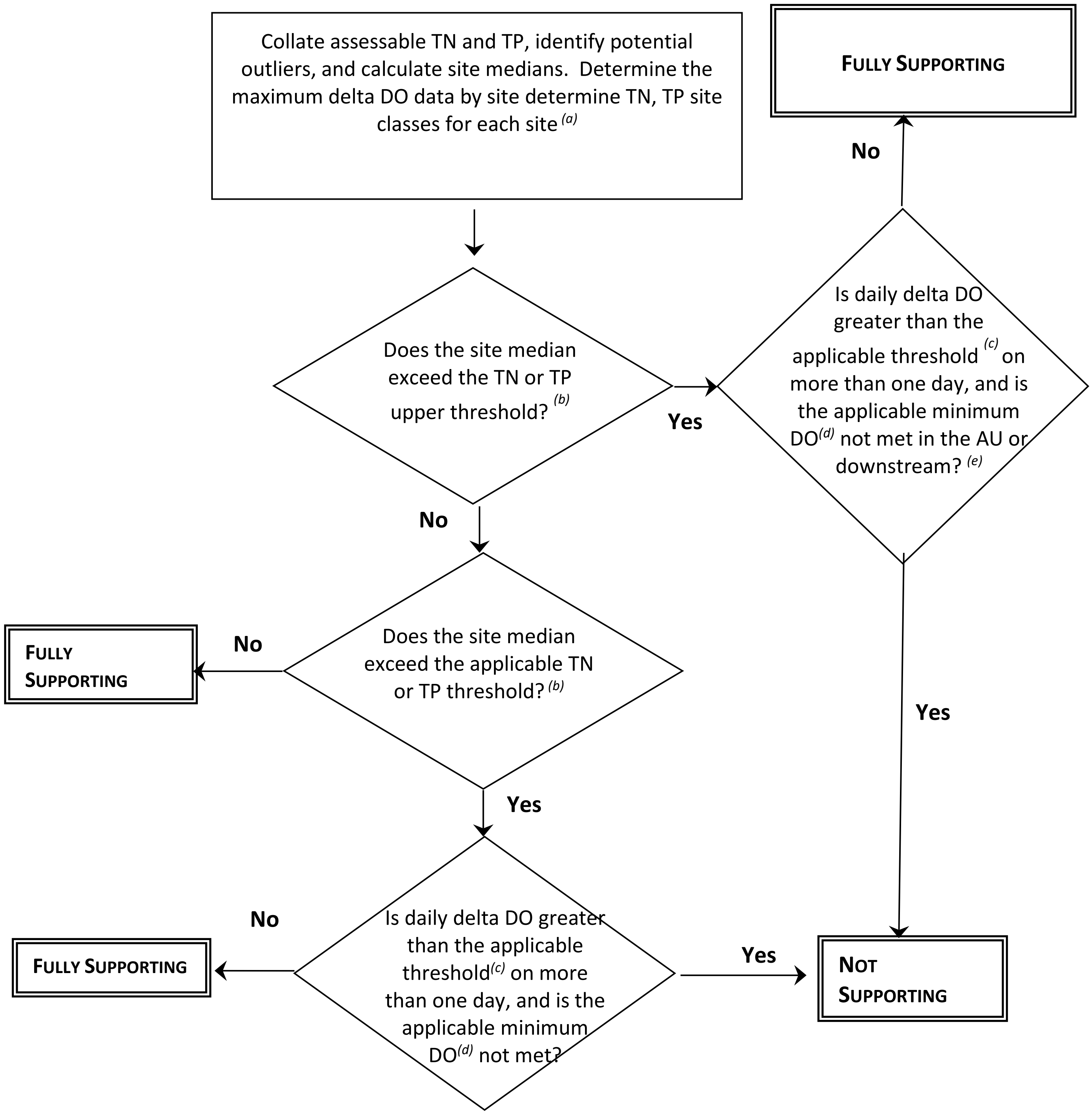

Figure 4. Generalized flowchart for determining nutrient impairment

NOTES: [a] Based on Table 1 and 2. [b] Based on Table 3. Site medians are determined using a minimum of 4 samples. [c] Based on Table 4. [d] Based on 20.6.4.900.H. [e] Before any potential influence from site-specific influences such as incoming major tributaries, diversions, ground water influences, etc. Data must be from a perennial downstream AU that falls within the scope of this protocol (i.e., not an exempted river, or lake/reservoir).

Water quality criteria for DO concentrations are found in 20.6.4.900.H NMAC. DO concentration will additionally be assessed as a separate parameter, following the procedures detailed in the DO Listing Methodology (https://www.env.nm.gov/swqb/protocols/, Appendix E). If DO concentration and nutrients are both determined to be **Not Supporting** via their respective listing methodologies, the AU will be listed for nutrients because the minimum DO is likely a response to excessive nutrients.

There are a few instances of segment-specific TP criteria in 20.6.4.101 - 20.6.4.899 NMAC. These will not be used to determine impairment of the narrative nutrient criteria found at 20.6.4.13.E. TP will additionally be assessed as a separate parameter in these cases, following the procedures detailed in Section 3.1 of the main Listing Methodology (https://www.env.nm.gov/surface-water-quality/calm/).

Table 6. Interpreting nutrient causal data

TYPE OF DATA	DOES NOT INDICATE ENRICHMENT	INDICATES ENRICHMENT	NOTES
•Nutrients (total nitrogen or total phosphorus[a])			
A) 0 to 3 samples	**A**) Not assessed.	**A**) Not assessed.	Applicable thresholds are found in Table 3.
B) >3 samples[b]	**B**) Site median does not exceed threshold value	**B**) Site median exceeds threshold value	

NOTES:

[a] Segment-specific TP criteria in 20.6.4.101 - 20.6.4.899 NMAC will not be used to determine impairment of the narrative nutrient criteria found at 20.6.4.13.E NMAC.

[b] Site medians are determined using a minimum of 4 samples.

Table 7. Assessing daily delta DO response data

TYPE OF DATA	DOES NOT INDICATE ENRICHMENT	INDICATES ENRICHMENT	NOTES
• DO Continuously recorded data (≥72 hours, ≤ one-hour frequency interval)	Daily delta DO is less than or equal to the applicable threshold.	Daily delta DO is greater than the applicable threshold for more than one day, and the applicable DO criterion is not met.	Applicable delta DO thresholds are found in Table 4, using TP site classes. Applicable DO criteria are found at 20.6.4.900.H NMAC.

NOTES: Daily delta DO is defined as the difference between the maximum and minimum DO concentration within a 24-hour period.

If there are multiple sites in the AU and the assessment results are not in agreement, the AU as currently defined may not represent homogeneous water quality. In this case, potential AU breaks will be examined. If none can be determined, the assessment for the downstream station will be given priority because water flows downhill.

REVISION HISTORY:

2012 listing cycle - Substantially re-organized protocol.

2014 listing cycle – **Pre-Public Comment**: Changed terminology from "Level 1 Nutrient Assessment" to "Nutrient Screening," and "Level 2 Nutrient Assessment" to "Nutrient Assessment." Full Support determinations from Nutrient Screenings are now considered preliminary and must be confirmed once all laboratory data are available. Changed data requirement to clarify that all Level 2 Nutrient Survey parameters – TN/TP, DO and pH sonde data (>72 hours), and chlorophyll *a* data – collected at the same station are required in order to perform a full Nutrient Assessment. Changed the chlorophyll *a* indicator to whether or not the upper limit of the threshold range is exceeded. Added clarification on how to assess multiple chlorophyll *a* samples when available. **Post Public Comment:** Minor wording clarifications/revisions. Clarified how the assessment approach addresses the "…*from other than natural* …" portion of the WQS. Changing wording in Table 6 to more clearly explain how multiple chlorophyll *a* samples are assessed.

2016 listing cycle – Revised to indicate that all indicators must be available to determine Full Support while Non Support can be determined with a partial dataset. Revised to include alternative collection time (two weeks into the growing season), and alternative Dissolved Inorganic Nitrogen calculation in the absence of useable TKN data. Added discussion of Future Direction and status of collaborative threshold revision project with EPA. Removed pH as a response variable based on analyses done as part of this project by (Ben Jessup, personal communication) combined with the lack of demonstration as a useful indicator in nutrient assessments completed between 2004 and 2014.

2018 listing cycle – **Pre-Public Comment**: Complete re-write to incorporate revised TN, TP, and delta DO thresholds based on stressor-response analyses completed collaboratively with Tetra Tech, Inc., EPA Region 6, and the EPA Office of Water Nutrient Scientific Technical Exchange Partnership and Support (N-STEPS) program. Removed alternative TN calculation using Dissolved Inorganic Nitrogen in the absence of useable TKN data based on rarity of occurrence and consistency with how missing data are handled in other listing methodologies. Term "assessment protocol" changed to "listing methodology" throughout. Changed Table 6 from "1 to 10" to "2 to 10" because n=2 is a minimum data requirement for assessment (added related footnote). Added discussions on persulfate digestion TPN method, how to handle MRLs above the application threshold, and how to assess concurrent TN Calculated and TN persulfate data. **Post Public Comment** Clarified why certain river segments are assessable using this revised listing methodology. Added additional description of quantile selection to the N-STEPS section in 2.0. Added an additional assessment step of verifying the presence of a downstream response when the upstream AU response is not documented due to displacement effects. Revised to note that it is necessary to document nutrient enrichment with a concurrent response (either in the AU or downstream AU) to determine impairment. Added additional information on persulfate digestion TPN method.

2020 listing cycle – **Pre-Public Comment:** Added additional information in the Exclusion section regarding streams that are naturally extremely shallow or low flow. Clarified TP High-Volcanic class, which now includes entire Jemez sub-basin as was the original intent. Revised DO sonde deployment table to clarify the preferred deployment is during the growing season. Added reference to SWQB Field Sampling Plans for additional sonde deployment information. Revised TN Flat, TN Moderate, and TP High-Volcanic thresholds to the 90^{th} quantile to acknowledge evidence of naturally-higher levels of nutrients in these site classes, and changed the threshold comparisons to site medians, based on the NSTEPS analyses (Jessup et. al 2015). Added discussion of J-flagged data and clarified detection limit concerns and approaches when determining TN Calculated.

Added approach to identify potential outliers. Added clarification that delta DO must be exceeded on more than one day, and that the min DO must also not be met to be considered an indication of enrichment. **Post-Public Comment:** Clarified that waters under 20.6.4.136 and 20.6.4.137 NMAC are excluded due to their ephemeral and intermittent stream types, respectively. Reverted the river reach exclusions list back to the 2015 listing methodology to allow adequate time for future consideration of the applicability of the N-STEPS thresholds developed in Jessup et. al (2015) to these larger systems, to incorporate the results of the large river biological condition gradient study in progress, and to consider additional weight-of-evidence parameters into subsequent proposed nutrient assessment approaches for these larger systems. Changed the minimum number of samples required to determine a site median from 8 to 4 to be consistent with the minimum requirement for assessment of other parameters.

REFERENCES:

American Public Health Association, American Water Works Association, and Water Environment Federation (APHA et. al). 2018. Standard Methods for the Examination of Water and Wastewater, 23rd Edition. Washington, D. C.

Art, H.W. 1993. Eutrophication, *in* Art, H.W., ed., A dictionary of ecology and environmental science (1st ed.): New York, New York, Henry Holt and Company, p. 196.

Chessman, B.C., P.E. Hutton, and J.M. Burch. 1992. Limiting nutrients for periphyton growth in subalpine, forest, agricultural and urban streams. Freshwater Biol. 28:349-361.

Jessup, B.K., S. Joseph, B. Dail, L. Guevara, S. Lemon, S. Murray, F. John, J. Oliver, L. Yuan, C. Patrick, M. Maier, and M. Paul. 2015. New Mexico nutrient thresholds for perennial wadeable streams. August 21, 2015. Prepared in cooperation with the New Mexico Environment Department, and the U.S. EPA Region 6 and the N-STEPS Program. Tetra Tech, Inc., Montpelier, VT. Available at: https://www.env.nm.gov/surface-water-quality/nutrients/.

Mallin, M.A., V.L. Johnson, S.H. Ensign and T.A. MacPherson. 2006. Factors contributing to hypoxia in rivers, lakes and streams. Limnology and Oceanography 51:690-701.

Miltner, R.J. and E.T. Rankin. 1998. Primary nutrients and the biotic integrity of rivers and streams. Freshwater Biology 40: 145-158.

New Mexico Environment Department Surface Water Quality Bureau (NMED/SWQB). 2016. Refinement of stream nutrient impairment thresholds in New Mexico: Summary Report. Santa Fe, NM. Available at: https://www.env.nm.gov/surface-water-quality/nutrients/.

Sabater, S., V. Acuña, A. Giorgi, E. Guerra, I. Muñoz, and A.M. Romani. 2005. Effects of nutrient inputs in a forested Mediterranean stream under moderate light availability. Archiv für Hydrobiologie, 163: 479-96

Sand-Jensen, K., T. Riis, O. Vestergaard, and S.E. Larsen. 2000. Macrophyte decline in Danish lakes and Streams over the past 100 years. J. Ecol. 88:1030-1040.

Simon, T.P. and J. Lyons. 1995. *Application of the index of biotic integrity to evaluate water resource integrity in freshwater ecosystems*. Pages 245–262 *in* Biological assessment and criteria: tools for water resource planning and decision-making (W.S. Davis and T.P Simon, eds.). Lewis Publishers, Boca Raton, Florida.

Stockner, J.G., E. Rydin, and P. Hyenstrand. 2000. Cultural oligotrophication: Causes and consequences for fisheries resources. Fisheries 25:7-14.

United States Environmental Protection Agency (EPA). 2000. Nutrient criteria technical guidance manual: Rivers and Streams. EPA-822-B-00-002. Office of Water, Office of Science and Technology. Washington, D.C.

_______. 2009. Empirical approaches for nutrient criteria derivation. Science Advisory Board Review Draft. Office of Water, Office of Science and Technology. Washington, D.C.

_______. 2010. Using stressor-response relationships to derive numeric nutrient criteria. EPA-820-S-10-001. Office of Water, Office of Science and Technology. Washington, D.C.

Welch, E.B., R.R. Horner, and C.R. Patmont. 1989. Predictions of nuisance periphytic biomass: a management approach. Wat. Res. 23(4): 401-405.