Nutrient Criteria Development Plan

Texas Commission on Environmental Quality

Texas Surface Water Quality Standards

10/23/2012

This document is an initial draft produced for review by the Surface Water Quality Standards Workgroup, TCEQ staff, and EPA. A final version will be published on TCEQ's Nutrient Criteria Development webpage following final approval. Information and content presented is for review purposes only.

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A. Executive Summary

The Texas Surface Water Quality Standards (TSWQS) include a narrative nutrient criterion that applies to all waters in the state, as well as site-specific numerical nutrient criteria for chlorophyll *a* for 75 reservoirs. These numeric criteria were adopted by the Texas Commission on Environmental Quality (TCEQ) in 2010, and are pending approval by the United States Environmental Protection Agency (EPA).

TCEQ will continue to develop and evaluate criteria 1) to maintain water quality in water bodies that are relatively un-impacted, 2) to maintain uses of water bodies, and 3) to identify and restore eutrophic water bodies associated with excessive nutrients. TCEQ will also continue to develop and improve procedures to assess compliance with criteria and to evaluate and control potential nutrient impacts through wastewater permits and other regulatory actions.

Future efforts for nutrient criteria will focus on 1) reviewing existing reservoir criteria and 2) proposing criteria for selected streams and rivers, estuaries, wetlands, and additional reservoirs. This effort will be staged over several years, and TCEQ staff will provide drafts of criteria for review by the public and by the EPA throughout the process. As criteria are developed for selected water bodies, they will be considered in subsequent triennial revisions of the TSWQS.

B. Purpose

This plan is intended to provide a framework for the continued development of numeric nutrient criteria for the state of Texas. TCEQ staff, in conjunction with the Surface Water Quality Standards Advisory (SWQSAWG) and Nutrient Criteria Development Advisory (NCDAWG) Workgroups, are evaluating options for consideration by EPA in future revisions of the Texas Surface Water Quality Standards (Chapter 307 in Title 30 of the Texas Administrative Code). This plan outlines the work to be performed, status of data analyses, options for criteria development, and estimates of time frames for developing and considering nutrient criteria. The information in this plan is subject to revision as more information is collected, evaluated, and reviewed by the TCEQ, stakeholders, and the EPA.

C. Current Status of Nutrient Regulation in Texas

TCEQ has adopted chlorophyll *a* criteria for 75 reservoirs; these criteria are currently under EPA review and will not be implemented unless approved by EPA[1]. The site-specific numeric nutrient criteria for selected reservoirs are described in section F of this document. In addition, TCEQ regulates nutrients by 1) applying narrative criteria to address permitted nutrient loadings at sites of concern, 2) developing watershed rules which require nutrient reductions in wastewater discharges in or near specified water bodies, and 3) employing the TCEQ's antidegradation policy to increases in discharge loads of nutrients. The TCEQ also considers phosphorus, nitrogen and, chlorophyll *a* ambient monitoring data to identify areas of concern in the biennial Texas Integrated Report (IR) for Clean Water Act Sections 305(b) and 303(d).

D. Scope of Criteria Development

TCEQ is exploring several complementary strategies to develop nutrient criteria. Strategies now being investigated include the following: 1) basing criteria on historical "ambient" averages or percentiles of nitrogen and phosphorus, with a statistical allowance for variability; 2) basing criteria on direct response indicators of eutrophication, such as chlorophyll *a*; 3) developing "translator" procedures that relate concentrations of nitrogen and phosphorus to direct indicators of eutrophication; and 4) developing criteria based on the effect of nutrients or indicators of eutrophication on other designated uses, such as aquatic life and/or public water supply. All of these options will consider the use of multiple parameters and "weight-of-evidence" to develop and implement criteria. Furthermore, there will be consideration to relationships of the overall watershed, basin, and down stream uses in the development and implementation of criteria.

[1] Appendix F – Site-specific Nutrient Criteria for Selected Reservoirs, 2010 TSWQS http://www.tceq.texas.gov/waterquality/standards/2010standards.html

E. History of Nutrient Criteria Development in Texas

Historical Planning and Stakeholder Coordination

TCEQ initially established a nutrient criteria development plan in 2001. The plan was revised in 2004 and in November 2006. EPA concurred that the last plan was "mutually acceptable" in a letter in February 2007.

In addition to the long-term TCEQ advisory workgroup on water quality standards, TCEQ convened a special-purpose standing advisory group in 2002 to help develop nutrient criteria (see Section H and Appendix C for additional information).

Historical Monitoring and Data Availability to Assess Nutrients

Over the past 40 years, TCEQ and partners have collected routine monitoring data, including nutrients, at numerous fixed station locations in reservoirs, streams and rivers, and estuaries. Sampling frequencies are often quarterly; and nutrient related parameters can include total phosphorus (TP), species to calculate total nitrogen (TN), water-column chlorophyll *a*, transparency (Secchi), 24-hour dissolved oxygen average and minima. Composition and abundance of fish and benthic invertebrates have been collected at selected sites. There are currently about 1,800 active fixed stations in Texas, and (as an example) total phosphorus was collected at about 1,531 stations in 2011, for a total of approximately 6,768 TP samples collected over the year.

Improvements in methodology for fixed stations have included changing to fluorometric methods for chlorophyll *a* during 2000-2003. TCEQ and monitoring partners have recently initiated ongoing updates to lab methods for TN and TP to achieve lower quantification levels. Furthermore, TCEQ staff have developed procedures to implement routine estimates of algal coverage in wadeable streams – based on the results of a recent comparative study of methods on Texas streams.

In addition to long-term fixed monitoring stations, TCEQ and others have conducted a wide variety of nutrient-related special studies over shorter time frames. Roughly 200 TCEQ Intensive Surveys over the past 40 years have provided relatively closely-spaced longitudinal gradient measurements of nutrients, 24-hour dissolved oxygen, flow, and other parameters in streams, reservoirs, and tidal rivers/estuaries.

TCEQ and the Texas Parks and Wildlife Department (TPWD) have conducted synoptic surveys of 72 "least-impacted" streams that included a variety of nutrient, water quality, habitat, and biological measurements. These studies provided the basis for the development of fish and invertebrate Indices of Biotic Integrity (IBI's) in Texas. Twenty years later, TCEQ is conducting follow-up studies on these streams.

TPWD has conducted 179 reservoir fisheries assessments over a number of years, and these studies include estimates of the percent coverage of attached vegetation.

Several synoptic studies have been recently conducted of nutrients, attached algae, and water quality in streams in large-scale watersheds. TCEQ has sponsored several such studies, including 15 streams in Central Texas (USGS), 20 streams in East Texas, and 30 streams in South Central Texas (Texas AgriLife Research and others). EPA Region 6 funded and coordinated a study by Baylor University and Texas AgriLife Research to conduct sampling and evaluation of nutrient impacts in 64 streams in the North Central Brazos and Trinity River Basins. TPWD conducted additional nutrient studies on six streams in the Central Brazos River Basin.

Historical Nutrient Evaluations

Some of the sampling studies described above, such as the large-scale watershed studies, have also included statistical analyses of ecological response levels to nitrogen and phosphorus. Additional examples to evaluate nutrient effects include: (1) recommended procedures to evaluate eutrophication in Texas reservoirs by the Center for Research in Water Resources (1987), (2) an extensive TMDL for

phosphorus in the North Bosque River, and a TMDL to protect dissolved oxygen (and phosphorus) in Lake O' the Pines, (3) statewide evaluation of concerns for phosphorus, nitrogen, and chlorophyll *a* for individual streams, reservoirs, and estuaries in the biennial TCEQ Integrated Report, and (4) trophic assessment of major reservoirs in Texas, also in the TCEQ Integrated Report, and (5) proposed procedures to evaluate and control potential nutrient impacts from wastewater discharges. Additional descriptions of new/ongoing nutrient evaluations are in Section G of this document.

Evaluating Nutrients in Permitted Wastewater Discharges

Prior to 2010, TCEQ evaluated potential nutrient impacts for applications for new or expanded wastewater discharges on a case-by-case basis. Evaluations were typically conducted for discharges in or near reservoirs, relatively clear streams and rivers, known occurrences of nuisance levels of algae or other aquatic vegetation, or public concern. In addition, watershed rules (Title 30, Chapter 311, Texas Administrative Code) have been adopted for eight specific sensitive watersheds that either prohibit domestic discharges or require phosphorus effluent limits. Permit reviews based on these evaluations and the watershed rules have resulted in effluent limits for total phosphorus in about 40 permits for domestic wastewater discharges.

Criteria Development for Reservoirs

Operating under the previous development plans, TCEQ and stakeholders evaluated options and conducted the following supporting analyses for reservoir nutrient criteria:

(1) Recalculating EPA's national regional criteria using only data for Texas reservoirs (with USGS),

(2) Combining user surveys with simultaneous water quality data to evaluate the potential for concentrations of chlorophyll *a* that were supportive of recreational/aesthetic uses (Texas Water Conservation Association, Trinity River Authority and numerous other river authorities),

(3) Calculating criteria for individual reservoirs for chlorophyll *a*, total phosphorus, and transparency (Secchi) – as an upper prediction interval based on historical data,

(4) Dividing reservoirs into three groups depending on potential human-induced nutrient loadings (low, moderate, high),

(5) Evaluating other ways to group and categorize reservoirs based geographic, physical, and hydrologic factors (with USGS),

(6) Evaluating a variety of statistical approaches to define the relationship of nutrients with chlorophyll *a* and transparency (with USGS and the nutrient criteria advisory workgroup).

These evaluations indicated that 1) statistically robust groupings of Texas reservoirs were not identified, so that the initial set of criteria needed to be based on historical data for individual reservoirs; and 2) the best statistical relationships (regressions) relating chlorophyll *a* with total phosphorus were obtained using long term reservoir means rather than individual sampling dates or other aggregations.

A number of participants in the nutrient advisory group recommended that 1) criteria be based on water-column chlorophyll *a*, with consideration of other parameters for assessing compliance as appropriate, and that 2) criteria be adopted for as many reservoirs as could be reasonably supported with available historical data.

TPWD also suggested alternative criteria calculations using nonparametric calculations that were based on statistical control charts to assess compliance with a relatively high percentile of historical data. TCEQ will continue to evaluate nonparametric options and other ways to better address non-detect data in future criteria development, as discussed in subsequent sections.

For the standards revisions proposed in 2010, TCEQ requested public comment on two options: 1) “stand-alone” chlorophyll *a* criteria, and 2) chlorophyll *a* criteria that would require confirmation by an exceedance of a screening values for transparency or for total phosphorus in order to list a reservoir as impaired for

nutrients. The initial set of criteria for 75 reservoirs were adopted by TCEQ in 2010, as described in the following section.

F. Adopted 2010 Reservoir Nutrient Criteria

In June 2010, TCEQ adopted site-specific Nutrient Criteria for Selected Reservoirs in Appendix F of the 2010 TSWQS[2]. These reservoir nutrient criteria are in the form of chlorophyll *a* criteria and represent the upper prediction interval of historical data collected at the main pool site in 75 reservoirs. The reservoir segment, segment description, main pool site identifier, and corresponding criteria are listed in Appendix F. The basic procedures that were used to calculate criteria, and notes on applying the criteria, are also available in Appendix F. Substantial additional documentation is available, as provided to EPA in August 2010, July 2011, October 2011, and February 2012. These criteria will not be used in the Integrated Report or in wastewater permitting until approved by EPA. Appendix F of the 2010 TSWQS is still under review by EPA (as of May 2012).

Assessing Criteria for Nutrients (chlorophyll a) in Reservoirs

Procedures to assess standards compliance with monitoring data are established in Section 307.9 of the TSWQS. . These procedures include 1) basing assessments on a long-term median concentration of chlorophyll *a*, 2) using near-surface samples collected in the main reservoir pools, and 3) using at least 10 samples for an assessment.

Implementing Nutrient Criteria in Wastewater Permits

Concurrently with the adoption of nutrient criteria, substantial new procedures to assess potential nutrient impacts from proposed wastewater discharges were established in the 2010 revisions to the *TCEQ Procedures to Implement the Texas Surface Water Quality Standards*. These new procedures incorporate basic water quality models to ensure that proposed new and increasing domestic discharges will

[2] Appendix F – Site-specific Nutrient Criteria for Selected Reservoirs, 2010 TSWQS http://www.tceq.texas.gov/waterquality/standards/2010standards.html

use up only a relatively small portion of the remaining assimilative capacity of chlorophyll a in an affected reservoir. Potential changes in chlorophyll *a* are predicted from modeled changes in phosphorus concentration by applying a regression equation.

In addition to an evaluation of numerical criteria, these procedures also establish a more defined framework for reviewing the potential localized impacts of new and expanding domestic discharges on streams and reservoirs. This review is based on the narrative criteria to protect for adverse nutrient impacts, in addition to the evaluation of numerical criteria described above. For this evaluation, a variety of site-specific "sensitivity" factors are assessed and individually weighted as low, moderate, or high concern. A composite score for all factors is used to indicate whether effluent limits for phosphorus are needed for a particular discharge. As of May 2012, all of the revised implementation procedures are pending approval by EPA.

G. Current Studies and Data Collection Efforts in Texas

Water Quality Standards Group Studies

There are several recent studies funded by EPA 106 grant money that will aid in the continuation of nutrient criteria development. The Texas Nutrient Data Collection Study Project performed by George Guillen, Ph.D., University of Houston Clear Lake produced a report summarizing national and statewide nutrient criteria development efforts. The report provided a historical review of 1) all nutrient data collected in Texas and conclusions of major nutrient/eutrophication studies performed on all water body types (excluding reservoirs) and 2) a detailed review of numerical nutrient criteria plans developed by other states for all water body types.

A second major study was performed by a team from Texas AgriLife Research-Stephenville and Texas Institute of Applied Environmental Research (TIAER) called the Texas Nutrient Data Collection Project. This study collected attached periphyton and low-level nutrient species from 30 established stream sites in the

Lower Brazos, Lower Colorado, and Brazos/Colorado Coastal River basins. The project examined the use of quantitative and qualitative periphyton collection techniques, and associated periphyton with low-level nutrient data from these waters. Study results will also assist in the development of rapid qualitative periphyton coverage methods to be incorporated into future TCEQ Surface Water Quality Monitoring (SWQM) sampling protocols.

The third recent project is Database Analysis to Support Nutrient Criteria Development which is ongoing through 2013. This project's key personnel are Brian E. Haggard, Ph.D., Principal Investigator and Co-Principal Investigators J. Thad Scott, Ph.D. and Michelle Evans-White, Ph.D., from the University of Arkansas. This project was initiated in 2011, and will provide advanced statistical analyses of water quality data and watershed information from Texas streams, rivers, and estuaries. Results will assist TCEQ in the development of numerical nutrient criteria by identifying potential groupings of water bodies with similar water quality and watershed characteristics, and investigating statistical methodologies to detect changes in response variables from nutrient concentrations. A detailed description of analysis is provided in the Nutrient Criteria Development Plans and Methodology section of this document.

Other TCEQ Studies

The Clean Rivers Program secured EPA 106 grant funding to collect additional nutrient species at lower levels of detection, particularly total Kjeldahl nitrogen (TKN), total phosphorus (TP), and chlorophyll *a*. Data at lower levels of detection is needed statewide to relate nutrient species with response variables such as aquatic vegetation and dissolved oxygen. Information collected through this effort will better identify overall range of nutrient concentrations in streams and reservoirs, thereby aiding criteria development.

Additionally, the Surface Water Quality Monitoring Team is revisiting the Texas Aquatic Ecoregion Project: Water Quality, In-stream Habitat, Biotic Integrity and Riparian Characteristics of Least Disturbed Streams in Texas. This project is a

continuation of the Texas Aquatic Ecoregion Project that originated in the early to mid-1980s. Since the late 1980's, sampling in least disturbed ecoregion reference streams has decreased. This study will consolidate and evaluate data collected since the original study and conduct additional surveys to better describe the current condition of least disturbed streams in Texas. During the upcoming 2012 sampling events, periphyton survey techniques may be incorporated into the study, increasing the availability of periphyton data use in criteria development.

Studies in Texas

Numerous special-purpose studies have been conducted to monitor and assess nutrients impacts and eutrophication in individual Texas water bodies – particularly reservoirs. These studies have been conducted by TCEQ, TPWD, the Texas Water Development Board (TWDB), river authorities, cities, environmental consultants, academic institutions, and others. Various studies of Texas estuaries, often by the Texas Development Board and Texas marine research institutes have assessed nutrient effects and the role of nutrient loadings. Some of these studies have addressed seagrass ecology, and nutrient-related impacts on seagrasses have been studied by research institutes and others. TPWD documents and maps seagrass distribution along the entire Texas coast, and both TPWD and TCEQ have been increasing efforts to sample abundance and ecological condition of seagrasses. In coordination with the Gulf of Mexico Program, recent ongoing studies on nutrient and algal relationships in Texas are being conducted by the University of Texas Marine Science Institute (Edward Buskey) and by Texas A&M University at Galveston (Antonietta Quigg).

H. Public Participation

Nutrient Criteria Development Advisory Workgroup

The TCEQ has formed a diverse Nutrient Criteria Development Workgroup (NCDAWG)[3] to obtain ongoing stakeholder input specifically about nutrients. This

[3] Nutrient Criteria Advisory Workgroup
http://www.tceq.texas.gov/waterquality/standards/stakeholders/nutrient_criteria_group.html

group is comprised of stakeholders from state and federal agencies, Texas river authorities, cities, industry, environmental groups, agriculture representatives, and other interested parties. Six work sessions were conducted leading up to the 2010 TSWQS revision. The workgroup reconvened on June 20, 2011, when updates on the site-specific reservoir criteria adopted by the commission, national criteria development, and plans for the upcoming 2013 triennial revision were provided. Information regarding joint meetings leading up to the 2010 TSWQS can be accessed at the SWQSAWG[4] documents webpage. The next NCDAWG meeting is planned for late Fall 2012.

I. Nutrient Criteria Development Plans and Methodology

TCEQ will be drawing from several methodologies to continue development of numeric nutrient criteria. These include: 1) historical analyses of nutrient data collected at individual water bodies and 2) historical analyses of data assembled into logical groupings based on water quality and/or watershed characteristics, and 3) stressor / response methodologies. The EPA has published guidance on all methodologies. See Appendix A for a list of recent EPA guidance documents.

The TCEQ will be using advanced statistical analysis of water quality data and watershed characteristics to assist in the development of criteria options for streams and rivers, tidal streams, and estuaries. TCEQ will also use these techniques to revise adopted site-specific reservoir criteria as needed. The relationships of nutrient parameters to response variables are complex, and require advanced statistical analysis to develop defensible criteria for the diverse array of water bodies in Texas.

It is important to note that although specific statistical analysis of water quality data and other variables may be approached on a water body type basis, ultimately the relationships and groupings will be examined using basin and watershed attributes to ensure continuity. This will ensure consideration is given to overall systems and downstream uses. Furthermore, the analysis described in each section

[4] Surface Water Quality Advisory Workgroup Meeting Documents
http://www.tceq.texas.gov/waterquality/standards/stakeholders/swqsawg_docs.html

for rivers, estuaries, and further examination of reservoirs will be conducted congruently and considered together at the conclusion of the statistics study described in Section G. The organization by water body type in Section K describes the aspects of analysis specific to each water body type.

A preliminary schedule of tentative target dates is presented in Appendix D. Major steps and time frames for revisions of the TCEQ's water quality standards are noted in Appendix E.

General Approach for all Water Body Types

TCEQ staff and contractors will follow these key steps in the criteria development process:
(1) Identify available data,
(2) Identify potential water body groups (including reference groups) from shared water quality and watershed characteristics,
(3) Perform preliminary, descriptive statistical analyses on historical data to characterize the available dataset,
(4) Analyze variability among historical nutrient data and select response variables for each water body type,
(5) Identify relationship of nutrient stressors to response variables.

These steps are described in detail in the sections below.

Availability of Data

For analysis of nutrient criteria TCEQ will use data readily available in the Surface Water Quality Monitoring Information System (SWQMIS)[5] database. A list of parameters of interest in provided in Appendix B. Data will include 1) information on water body type (estuaries, rivers and streams, and lakes/reservoirs), 2) segment and station identifiers and geographical locations of sampling stations, and 3) results for water quality parameters such as chlorophyll-*a*, total phosphorus,

[5] SWQMIS http://www.tceq.texas.gov/waterquality/data-management/wdma_data.html

total nitrogen and nitrogen components, transparency (if applicable), dissolved oxygen (e.g., 24-hour mean, min and max), pH, temperature, conductivity, total suspended solids, and data on fish, benthos, and algal communities, as well as other available ancillary data (as applicable).

Identification of Potential Water Body Groupings

Watershed characteristic and water quality data will be considered to identify statistically significant groupings of water bodies. Information considered will include: type of water body, river basin boundary, level III and/or IV ecoregion, percent land use, hydrologic unit code watershed boundaries, and presence of wastewater discharges, and confined animal feeding operations.

Specific examples of characteristics to consider for grouping rivers and streams include river basins, ecoregions, average depth, wadeable versus non-wadeable flow, average and dry-weather flows, percent of flow from wastewater discharges, extent of spring-fed flow, tidal influence, water chemistry, land use, substrate type (e.g., gravel, incised sand/clay bottom, sand, bedrock), and extent of tree canopy.

Reference groupings for each water body type will consider geographic, hydrologic, physical, chemical, and biological characteristics, and will be based on statistical analyses such as regression trees. This task will include a process to identify water bodies with relatively low impacts. Identification of potential impact level (e.g. -- low, medium, and high) will consider factors such as land use distribution (urban development and broad agricultural classifications), location and size of domestic wastewater discharges, number of confined animal operations, catchment area, and stream flow. Groupings of reference estuaries in Texas can also be evaluated, but the small number of estuary systems may limit this approach.

Preliminary Analyses of Data

The TCEQ will use descriptive statistics to characterize available data, and investigate statistical methods to address data results below reported detection limits. Such methods include estimating descriptive statistics for censored values,

such as robust regression on ordered statistics. These methods will minimize the effect of censored data on additional analyses.

Statistical analyses will occur on an individual water body basis, and within groupings. Data characterization will include substitution of censored data and/or estimation for non-detects, and calculation of new variables as needed (i.e., calculating total nitrogen, salinity, etc.). Summary analysis of these datasets will include calculation of descriptive statistics by site and segment, frequency distributions, data transformations, and evaluation of nutrient stressors and response trends over time.

Historical Analysis

The TCEQ will examine historical data from each water body type to investigate statistically significant variability of water quality collected from individual representative sites. Water Quality parameters of interest include water-column chlorophyll *a*, transparency, total phosphorus, and nitrogen parameters. Statistical evaluations to incorporate variability at single sites may include parametric and nonparametric prediction intervals (dependent upon the distribution of data), and upper confidence intervals.

Potential options for criteria development, based solely on historical analyses of available data, will incorporate a “weight of evidence” approach using multiple parameters to develop criteria and determine attainment. The evaluation will include a comparison of data collected year-round, versus results from only warm seasons.

Analyses will also be performed on identified groups of similar water bodies for each major water body type, as well reference groups. These will include the same approaches as described for individual sites, but applied to water bodies within a reference group. This evaluation will include an assessment of 1) the potential effectiveness of grouping similar water bodies, and 2) the potential effectiveness of extrapolating results for selected reference water bodies to all water bodies within a similar group.

Stressor Response Analysis

The TCEQ will evaluate the statistical relationships between nutrient concentrations (stressors) and response variables for individual water bodies and within groupings for each water body type. Specific stressor variables to consider will include total phosphorus and total nitrogen (or surrogate nitrogen components). Specific response variables will vary for each water body type, and may include the following combinations:

Reservoirs and estuaries – water column chlorophyll-*a,* transparency, and 24-hour range of dissolved oxygen fluctuations (where available).
Large streams and rivers - water column chlorophyll *a*, transparency, 24-hour range of dissolved oxygen fluctuations, biological indices for fish and benthic invertebrates.
Small streams and rivers - periphyton (where available), transparency, and 24-hour range of dissolved oxygen fluctuations (where available).

J. Data Limitations

The TCEQ has a large historical data base that contains monitoring data from as early as the 1970s. There are inherent limitations of any data set when developing nutrient criteria in particular. The TCEQ has identified the following issues below that must be considered during the criteria development process.

Parameters important to nutrient criteria development such as nitrogen, phosphorus, chlorophyll *a*, transparency, and 24 hour dissolved oxygen were often not collected as paired samples, or were intermittently reported. Parameters such as total nitrogen were often not directly measured and need to be calculated using the individual nitrogen species (i.e., nitrate, nitrite, and total Kjeldahl nitrogen). Quality indicators to identify level of detection vary in type and reporting level within the data set, limiting the range of sensitivity in data reported. Issues similar to those in surface water have been addressed in ground water. EPA has produced

a document dealing with analysis of non-detects in groundwater, which may be an useful resource for consideration when conducting parametric analysis[6]. In addition, many of these issues have been improved upon by the TCEQ and its partners in the Clean Rivers Program. Future data analysis will target lower levels for nutrient species, and efforts are being implemented to collect paired parameters as part of routine monitoring. These changes will result in a better dataset available for use in criteria development.

Data showing the effect of nutrients on attached algae or rooted macrophytes in Texas streams is limited. Not only is there limited data on concentrations of chlorophyll *a* and nutrients in attached vegetation, there is also sparse data on the coverage of the attached vegetation, either algae or rooted macrophytes. Additional information on attached vegetation, chlorophyll *a*, and nutrients will allow the TCEQ to best use the substantial data available on water column chlorophyll *a* and nutrients. In smaller streams and rivers, (and in some shallow, larger rivers dominated by macrophytes), chlorophyll *a* in the water column does not appear to be as useful an indicator of nutrient enrichment as chlorophyll *a* in attached algae (periphyton). More study is needed to determine if chlorophyll *a* in attached algae is a more suitable response variable in Texas streams.

Available water quality data for wetlands is very limited. Basic sampling for nutrient concentrations, water column chlorophyll *a*, attached vegetation, and 24-hour dissolved oxygen is needed to describe water quality for wetlands in Texas. Baseline data would provide a means to determine the following:
(1) Assess wetland nutrient and vegetative characteristics under relatively un-impacted conditions,
(2) Define nuisance levels of enrichment and aquatic vegetation,
(3) Establish the relationship between nutrients and growth of wetlands vegetation,
(4) Provide appropriate ambient concentrations on which to base criteria where the goal is to preserve existing conditions, and

[6] *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities EPA 530/R-09-007* http://www.epa.gov/osw/hazard/correctiveaction/resources/guidance/sitechar/gwstats/unified-guid.pdf

(5) Assess the point at which enrichment impairs wetlands functions and values

K. Nutrient Criteria Development Specifics by Water Body Type

Reservoirs

The TCEQ will continue to work on nutrient criteria development for reservoirs, pending EPA action on the adopted criteria listed in Appendix F of the 2010 TSWQS. Criteria based on historical ambient data from individual reservoirs can be appropriate for those reservoirs that are not eutrophic. The purpose of criteria for such reservoirs (termed "least impacted") is to maintain and protect existing conditions.

This approach reduces some of the high variability inherent in reservoir data. Initial factors used to identify and select "least impacted" reservoirs include the following:
(1) Availability of historical data to derive criteria,
(2) Limited urban and agricultural land use in the watershed,
(3) Absence of major discharges in the upstream watershed,
(4) No trend of increasing eutrophication, and
(5) Judgment of experts with firsthand knowledge of a reservoir's watershed and water quality characteristics.

The TCEQ may further refine these criteria by relating total phosphorus and total nitrogen to chlorophyll *a* criteria as part of a weight of evidence approach.

Streams and Rivers

Rivers and streams receive nutrient loads directly from point and non-point sources and can impact downstream reservoirs and estuaries. Due to the large number of streams and rivers in Texas receiving nutrient loads from point and non-point sources, it will be challenging to identify least impacted groupings. The purpose of nutrient criteria for least-impacted streams and rivers would be to maintain and protect existing conditions. Potential factors to identify and select least-impacted rivers are similar to those identified for reservoirs.

For larger rivers, where phytoplankton are an important component of eutrophication, the statistical relationship between nutrient concentrations and water-column chlorophyll *a* will be evaluated. The evaluation will begin with the historical data that exists on phosphorus, nitrogen, and chlorophyll *a*.

In small streams and in rivers, where rooted macrophytes are the primary form of eutrophication, there are limited data available on that could help define the nutrient/vegetation relationship. These data are available only from special-purpose studies on a limited number of streams and rivers.

Estuaries and Tidal Rivers

Texas estuaries can receive high nutrient loading from their contributing upstream watersheds. Excessive nutrients may contribute to a number of concerns in estuaries. These include increased hypoxia and turbidity, development of harmful algal blooms, and decreased productivity of seagrasses resulting from reduced light penetration. Although a very important water body type, nutrient criteria development for estuaries follows reservoirs and rivers in sequence due to:
(1) The high variability of nutrients, and complexity of relationship between nutrients and response variables,
(2) The emphasis of freshwater inflows and nutrients to boost fishery production,
(3) The larger watershed scale and diverse contributions of nutrients to tidal rivers and estuaries, and
(4) Less availability of information and studies to relate nutrient concentrations and loads to eutrophic conditions.

The TCEQ will follow the same criteria development process previously described for reservoirs and rivers, but will also consider effects of freshwater inflows and the role of nutrients in excessive phytoplankton blooms. The uniqueness of estuarine features including tidal rivers, shallow transitional estuaries, the transition zone between advective rivers and open estuaries, and open bays will require additional consideration in the criteria development process. These relationships will be considered holistically in the context of the river basin and its characteristics when

criteria are ultimately proposed anded and implementation procedures developed for all water body types.

The TCEQ currently evaluates nutrient additions from wastewater discharges on a case-by-case basis in accordance with narrative provisions in §307.4(e) of the Texas Surface Water Quality Standards. The TCEQ has recently considered nitrogen effluent limits from discharges to locally-sensitive estuarine areas. The TCEQ intends to continue to evaluate the narrative criterion for nutrients during triennial revisions of the standards to ensure this criterion facilitates implementation of interim control measures for nutrient loads.

Texas, in coordination with the Gulf of Mexico Program, has participated in Gulf of Mexico Alliance (GOMA) projects that address nutrient loadings to the Gulf of Mexico. Water resource agency and research staff from Louisiana, Mississippi, Alabama, Florida, and Texas have participated in conferences, workgroups and conference calls to share status of project development and progress. Information shared in this forum and from GOMA studies will assist in TCEQ's efforts to develop nutrient criteria.

Wetlands

Texas is estimated to have 6,471,000 acres of inland wetlands and 1,648,000 acres of coastal wetlands. Wetlands in Texas can be adversely impacted by excessive nutrient loadings, particularly from nonpoint sources. There are only a few instances where permitted wastewater is directly discharged into wetland areas.

EPA published a final guidance document for wetlands in 2008, The Nutrient Criteria Technical Guidance Manual: Wetlands[7] in support of the National Nutrient Strategy to develop water body specific nutrient criteria. This guidance suggests categorization of wetlands based on a reference condition approach, geography, environmental conditions, the Cowardian Classification System and/or some

[7] The *Nutrient Criteria Technical Guidance Manual: Wetlands Fact sheet* http://water.epa.gov/scitech/swguidance/standards/criteria/nutrients/wetlands/index.cfm

combination. Once a grouping system is established, develop nutrient criteria using a percentile approach or a stressor/response relationship. The guidance does point out the difficulty to defining these relationships. As mentioned in Section J, much more data collection is needed to define these relationships for Texas wetlands.

A few recent projects for wetlands construction or wetlands enhancement have collected data that could be useful for determining nutrient impacts. One example is a study funded by the City of Corpus Christi to assess the effects of an experimental wastewater diversion to a coastal wetland. Additionally, the 2011 National Wetland Condition Assessment (NWCA), which included Texas Wetlands, may provide useful data in the near future. The projected date for completion of the final NWCA report is 2013. Despite these localized studies, more investigation is needed to yield information on the types of data needed to develop nutrient criteria in wetlands.

Boundary Waters

Texas shares boundary waters with New Mexico, Oklahoma, Arkansas, Louisiana, and Mexico. The TCEQ recognizes that any eventual criteria for shared boundary waters need to be developed in close coordination with adjacent states, EPA, and the International Boundary and Water Commission (for reaches and reservoirs on the Rio Grande). The Regional Technical and Assistance Group for nutrient development will be utilized as a preliminary point of coordination for any criteria developed for boundary waters. The TCEQ also anticipates that separate interstate workgroups may be needed to establish nutrient criteria for shared waters.

As the TCEQ moves into developing criteria for reservoirs and rivers that border Texas and other states and Mexico, they will be contacting these entities to collaborate on nutrient criteria development. The TCEQ is currently participating in the EPA Region VI effort to consolidate and assess nutrient data on the Red River in order to establish a framework for coordinated development of nutrient criteria for this shared boundary water.

Appendix A – EPA Relevant Guidance and Important Reports

- Nitrogen and Phosphorus Pollution Data Access Tool
  http://water.epa.gov/scitech/swguidance/standards/criteria/nutrients/npdat_index.cfm
- State Development of Numeric Criteria for Nitrogen and Phosphorous Pollution
  http://water.epa.gov/scitech/swguidance/standards/criteria/nutrients/progress.cfm
- Resources for Developing State Criteria for Nitrogen and Phosphorus Pollution
  http://water.epa.gov/scitech/swguidance/standards/criteria/nutrients/criteria.cfm
- Memo: Working in Partnership with States to Address Phosphorus and Nitrogen through Use of a Framework for State Nutrient Reductions, March 2011
  http://water.epa.gov/scitech/swguidance/standards/criteria/nutrients/upload/memo_nitrogen_framework.pdf
- Nutrients in Estuaries, November 2010
  http://water.epa.gov/scitech/swguidance/standards/criteria/nutrients/upload/Nutrients-in-Estuaries-November-2010.pdf
- Using Stressor-response Relationships to Derive Numeric Nutrient Criteria, November 2010
  http://water.epa.gov/scitech/swguidance/standards/criteria/nutrients/upload/finalstressor2010.pdf
- Science Advisory Board Review of Empirical Approaches for Nutrient Criteria Derivation, April 2010 EPA-SAB-10-006

  http://yosemite.epa.gov/sab/sabproduct.nsf/95eac6037dbee075852573a00075f732/5972E2A88464D45E85257591006649D0/$File/Final+Draft+Empirical+Approaches+08-17-2009+for+EPEC+Sept+9-11+2009+Meeting.pdf
- Empirical Approaches for Nutrient Criteria Derivation – Science Advisory Board Draft, August 2009

  http://yosemite.epa.gov/sab/sabproduct.nsf/95eac6037dbee075852573a00075f732/5972E2A88464D45E85257591006649D0/$File/Final+Draft+Empirical+Approaches+08-17-2009+for+EPEC+Sept+9-11+2009+Meeting.pdf
- Nutrient Innovations Task Group Report, August 2009
  http://water.epa.gov/scitech/swguidance/standards/criteria/nutrients/upload/2009_08_27_criteria_nutrient_nitgreport.pdf

Appendix B – Types of Nutrient Criteria Development Data

Table 1 Nutrient Parameters

Parameter Code	Parameter Description	Parameter Measurement Unit
00620	Nitrate Nitrogen, Total (Mg/L As N)	MG/L
00615	Nitrite Nitrogen, Total (Mg/L As N)	MG/L
00630	Nitrite Plus Nitrate, Total 1 Det. (Mg/L As N)	MG/L
00610	Nitrogen, Ammonia, Total (Mg/L As N)	MG/L
00625	Nitrogen, Kjeldahl, Total (Mg/L As N)	MG/L
00593	No2 Plus No3-N, Total, Whatman Gf/F Filt (Mg/L)	MG/L
00665	Phosphorus, Total, Wet Method (Mg/L As P)	MG/L

Table 2 Response Variable Parameters

Parameter Code	Parameter Description	Parameter Measurement Unit
32211	Chlorophyll-A Spectrophotometric Acid.	UG/L
70953	Chlorophyll-A, Fluorometric Method	UG/L
89858	Dissolved Oxygen, # Of Measurements In 24-Hrs	NU
89857	Dissolved Oxygen, 24-Hour Avg. (Mg/L) Min. 4 Mea	MG/L
89856	Dissolved Oxygen, 24-Hour Max. (Mg/L) Min. 4 Mea	MG/L
89855	Dissolved Oxygen, 24-Hour Min. (Mg/L) Min. 4 Mea	MG/L
00400	pH (Standard Units)	S.U.
00403	pH (Standard Units) Lab	S.U.
00223	pH # OF MEASUREMENTS IN 24-HRS	NU
00215	pH S.U., 24hr Maximum Value	S.U.
00216	Ph, S.U., 24hr, Minimum Value	S.U.
89077	Transparency, Secchi Disc (Feet)	FT
00077	Transparency, Secchi Disc (Inches)	IN
00078	Transparency, Secchi Disc (Meters)	M
00222	Specific Conductance, # Of Measurements 24-Hr	NU
00212	Specific Conductance, Umhos/Cm, Field, 24hr Avg	uS/cm
00213	Specific Conductance, Umhos/Cm, Field, 24hr Max	uS/cm
00214	Specific Conductance, Umhos/Cm, Field, 24hr Min	uS/cm
00094	Specific Conductance,Field (Umhos/Cm @ 25c)	uS/cm
00095	Specific Conductance,Lab (Umhos/Cm @ 25c)	uS/cm
00010	Temperature, Water	DEG Centigrade
00211	Temperature, Water 24hr Min	DEG Centigrade
00209	Temperature, Water , 24hr Avg	DEG Centigrade
00011	Temperature, Water	DEG Fahrenheit
00221	Water Temperature, # Of Measurements In 24-Hrs	NU
00210	Water Temperature, 24hr Max	DEG Centigrade

Table 3 Potential Grouping Parameters

Parameter Code	Parameter Description	Parameter Measurement Units
00062	Elevation, Reservoir Surface Water In Feet	FT
00061	Flow Stream, Instantaneous (Cubic Feet Per Sec)	CFS
01351	Flow:1=No Flow,2=Low,3=Normal,4=Flood,5=High,6=Dry	NS
00065	Stage, Stream (Feet)	FT
74069	Stream Flow Estimate (Cfs)	CFS
00055	Stream Velocity (Feet Per Second)	FT/SEC
00004	Stream Width (Feet)	FT
NA	Fish Regional Index Of Biotic Integrity (Fish IBI)	Category
NA	Benthic Index Of Biotic Integrity (RBIBI)	Category
NA	Habitat Quality Index (Hqi)	Category

Table 4 Other Grouping Variables

Other Variables	Reasoning
Basin	Logical grouping of Segments and unique characteristics by basin
Ecoregion III	Biological data is examined on an Ecoregional Scale
Permitted Dischargers number and flow to receiving water upstream	Effect of permitted flow and potential point source of nutrients
USGS land use data	Potential non-point source of nutrients

Appendix C –Completed Milestones

Table C-1 Nutrient Criteria Development Plan Milestones

Task[8]	Date	Done
Send initial nutrient criteria development plan to EPA	11/30/2001	Y
Send revised draft Plan to EPA	1/31/2005	Y
Send revised draft Plan to EPA	12/1/2006	Y

[8] Nutrient Criteria Development Plan 2001 and 2006
http://www.tceq.texas.gov/waterquality/standards/stakeholders/nutrient_criteria_group.html

Table C-2 Nutrient Criteria Development Milestones

Task	Date	Done
Complete initial reservoir, and streams and rivers data base (USGS)	10/31/2001	Y
NCDAWG meeting 1[9]	5/8/2002	Y
NCDAWG meeting 2[9]	2/24/2003	Y
Establish final nutrient data base: 110 reservoirs; Jan 1970 - Apr 2003	12/19/2003	Y
Review scientific literature that links levels of algae and vegetation with impacts on water quality uses	12/31/2003	Y
NCDAWG meeting 3[9]	1/29/2004	Y
Develop draft list of least-impacted reservoirs	4/1/2004	Y
Evaluate trends over time of nutrients and chlorophyll *a*	4/21/2004	Y
Calculate preliminary draft criteria for selected least impacted reservoirs, based on confidence intervals for the means of chl *a*, TN, TP (80, 90, 95, and 99th confidence levels)	8/1/2004	Y
NCDAWG meeting 4[9]	3/15/2005	Y
NCDAWG meeting 5[9]	7/12/2005	Y
Send EPA preliminary staff draft of reservoir criteria	8/31/2005	Y
Conduct preliminary evaluation of criteria for selected rivers based on historical average conditions using EPA methodology	8/31/2005	Y
NCDAWG meeting 6[9]	9/26/2005	Y
Search peer reviewed literature for articles on nutrients and their impact on rivers and streams.	4/30/2006	Y
Design and populate ACCESS relational data base with reservoir data.	7/31/2006	Y
Stream data added to nutrient data base	7/31/2006	Y
Finish data collection on dissolved oxygen, biota, nutrients, and attached algae for 33 East Texas streams	8/31/2006	Y
Present current status of draft criteria to workgroup	3/1/2007	Y
Update workgroup on status of stream studies	3/1/2007	Y
SWQSAWG meeting for 2010 TSWQS #1[10]	3/7/2007	Y
SWQSAWG meeting for 2010 TSWQS #2[10]	5/16/2007	Y
SWQSAWG meeting for 2010 TSWQS #3[10]	6/26/2007	Y
Finish data collection on dissolved oxygen, biota, nutrients, and attached algae for Central Texas streams	7/31/2007	Y
SWQSAWG meeting for 2010 TSWQS #4[10]	9/6/2007	Y
Evaluate stream data on East and Central Texas streams, and apply results to consideration of nutrient criteria for streams. Deliverables from USGS due 7-31-07 for Central Texas streams.	9/30/2007	Y

[9] Information and documentation for these tasks are available on the NCDAWG webpage http://www.tceq.texas.gov/waterquality/standards/stakeholders/nutrient_criteria_group_summaries.html

[10] SWQSAWG meeting materials http://www.tceq.texas.gov/waterquality/standards/stakeholders/swqsawg_docs.html

Task	Date	Done
SWQSAWG meeting for 2010 TSWQS #5[10]	5/5/2008	Y
SWQSAWG meeting for 2010 TSWQS #6[10]	1/6-1/7/2009	Y
SWQSAWG meeting for 2010 TSWQS #7[10]	4/27/2009	Y
Propose and Adopt numerical nutrient criteria for Reservoirs, implementation procedures to be used in permitting, and updates on assessment procedures during triennial standards revision	6/21/2010	Y
NCDAWG meeting to update workgroup on 2010 TSWQS and upcoming plans	6/20/2011	Y
Revise 2012 implementation procedures to interpret the narrative nutrient criteria to be used in permitting[11]	1/21/2011	Y

[11] Procedures to Implement the TSWQS http://www.tceq.texas.gov/waterquality/standards/WQ_stds

Appendix D – Nutrient Criteria Schedule*

Table D-1 Nutrient Criteria Development Plan Schedule

Task	Estimated Timeframe	Completed Date
Update SWQSAWG 2013 meeting #1 of plan to update plan	Spring 2012	3/28/2012
Provide rough draft of plan at SWQSAWG 2013 meeting #2	Spring 2012	5/25/2012
Provide final draft of plan on NCDAWG Webpage.	Summer 2012	In Progress
Draft plan mutually agreed upon by the TCEQ, NCDAWG, and EPA	Fall 2012	In Progress
Revise draft plan as needed	Ongoing	

Table D-2 Reservoir Criteria Development Schedule

Task	Estimated Timeframe	Completed Date
Statistical analysis of potential groupings, historical data, and stressor/response relationships (including boundary waters)	September 2013	
Addition of nutrient parameters to reservoir criteria, dependent upon EPA approval or disapproval	Ongoing	

Table D-3 Stream and Rivers Nutrient Criteria Development Schedule

Task	Estimated Timeframe	Completed Date
Statistical analysis of potential groupings, historical data, and stressor/response relationships (including boundary waters)	September 2013	
Incorporate additional information on individual streams and rivers	Ongoing	
Expand/revise nutrient development plan and schedule for rivers and streams as needed	Ongoing	
During triennial standards revisions, consider expanded narrative criterion and new implementation procedures to address nutrient impacts in rivers and streams	Ongoing	
Consider numerical nutrient criteria for selected streams and rivers in the TSWQS, consider revisions as needed to the standards implementation procedures to be used in permitting, and update assessment procedures for nutrients as appropriate.	2016	

Table D-4 Estuary (Tidal Stream) Nutrient Criteria Development Schedule

Task	Estimated Timeframe	Completed Date
Statistical analysis of potential groupings, historical data, and stressor/response relationships (including boundary waters)	September 2013	
Expand/revise nutrient development plan and schedule for estuaries as needed	Ongoing	
During triennial standards revisions, consider expanded narrative criterion and new implementation procedures to address nutrient impacts in estuaries	Ongoing	
Consider proposals for numerical nutrient criteria for select estuaries during triennial standards revision	2016	

Table D-4 Wetlands Nutrient Criteria Development Schedule

Task	Estimated Timeframe	Completed Date
Review EPA guidance for wetland nutrient criteria	TBD	
Search for available data on Texas wetlands	Ongoing	
Update workgroup on status of wetlands database	TBD	
Review available data for data gaps	TBD	
Formulate needs and ways to fill data gaps and if necessary contracts	TBD	
Conduct preliminary evaluation of criteria for selected wetlands based on available data	TBD	
Expand/revise nutrient development plan and schedule for wetlands as needed	Ongoing	
Consider proposals for numerical nutrient criteria for wetlands during triennial standards revisions	TBD	

Table D- 5 Boundary Waters Nutrient Criteria Development Schedule

Task	Estimated Timeframe	Completed Date
Statistical analysis of potential groupings, historical data, and stressor/response relationships	September 2013	
Incorporate additional information on individual boundary waters and coordinate criteria development with Arkansas, Louisiana, Oklahoma, and the International Boundary and Water Commission.	Ongoing	
Expand/revise nutrient development plan and schedule for boundary waters as needed	Ongoing	
During triennial standards revisions, consider expanded narrative criterion and new implementation procedures to address nutrient impacts in boundry waters	Ongoing	
Consider numerical nutrient criteria for selected boundary waters in the TSWQS, consider revisions as needed to the standards implementation procedures to be used in permitting, and update assessment procedures for nutrients as appropriate.	Ongoing	

**All dates presented in this schedule are tentative and subject to change, and will be reflected in future revisions to this plan as needed.*

Appendix E: Timeline for Revising the Standards

Table E-1 TCEQ timeline from initiation of rulemaking to adoption for a triennial revision of Texas Surface Water Quality Standards Title 30, Chapter 307, Texas Administrative Code. The exact number of days will vary based upon calendar year; however, there is 6 months from the time a rule is proposed to the time it is adopted. Furthermore, if the 6 month time table is not met the rule revision will not proceed. All dates before proposal of the rule have no strict timeline and in a large revision year there may be additional workgroups before proposal.

Days	TASKS
0	Request for preliminary public comments
240	TCEQ initiates rulemaking
420	TCEQ convenes stakeholders workgroup
730	Preliminary draft of revisions for informal review
730	Revised draft revisions, preamble, and fiscal note
820	Draft revisions publicly approved by TCEQ Commissioners at Agenda
850	Notice of hearing in Texas Register and mail out (45 day comment period must close before the hearing can be held)
895	Public hearing
925	Draft of final revisions and responses to comments
985	Standards revisions adopted as state rule at TCEQ Agenda. Adopted standards published in Texas Register (third Friday after agenda)
1000	TCEQ sends adopted revisions to EPA for review and approval