U.S. ENVIRONMENTAL PROTECTION AGENCY – REGION 6

Technical Support Document

EPA Review of Reservoir-specific Chlorophyll *a* Criteria for 75 Texas Reservoirs

July 2013

Technical Support Document
EPA Review of Reservoir-specific Chlorophyll *a* Criteria for 75 Texas Reservoirs

Table of Contents

Overview 1

Background 1

Summary of Reservoir-specific Chlorophyll *a* Criteria for 75 Texas Reservoirs 1

Summary of Designated Uses the Reservoir-specific Chlorophyll *a* Criteria are Intended to Protect 2

EPA Review of Reservoir-specific Chlorophyll *a* Criteria for 75 Texas Reservoirs 2

Scientific Defensibility of TCEQ's Criteria Derivation Approach 3

Protectiveness of TCEQ's 75 Reservoir-specific Chlorophyll *a* Criteria 5

TCEQ Integrated Reports Identifying Impairments for Nutrient Enrichment-Related Indicators 6

TCEQ Integrated Reports Identifying Water Quality "Concerns" for Nutrients and Nutrient Enrichment-Related Indicators 7

Treated Drinking Water Chemical Data 8

Microcystin, Cyanobacteria, and Chlorophyll *a* Data from Texas Reservoirs Collected During EPA's 2007 National Lakes Assessment 8

TCEQ Chlorophyll *a* Trend Analysis Results (Statistical Significance of Trends) 9

EPA Chlorophyll *a* Trend Analysis Results (Rate of Chlorophyll *a* Accumulation) 10

TCEQ Trophic State Classification Information 11

Comparison of Reservoir-specific Chlorophyll *a* Criteria to Water Quality Management Thresholds Published in the Scientific Literature 12

Summary of EPA Actions on Reservoir-specific Chlorophyll *a* Criteria for 75 Texas Reservoirs 15

Tables 17

References 42

Technical Support Document
EPA Review of Reservoir-specific Chlorophyll *a* Criteria for 75 Texas Reservoirs

Overview

On June 30, 2010, the Texas Commission on Environmental Quality (TCEQ) adopted reservoir-specific chlorophyll *a* criteria for 75 Texas reservoirs, which are applicable to specific monitoring sites found within each of these reservoirs (see Texas water quality standards (TX WQS) §307.10, Appendix F).[1] These criteria were submitted to the U.S. Environmental Protection Agency (EPA) for review and approval on July 20, 2010. The purpose of this Technical Support Document (TSD) is to describe EPA's review of TCEQ's 75 reservoir-specific chlorophyll *a* criteria, as well as EPA's decisions to approve or disapprove the criteria under Clean Water Act (CWA) §303(c). In summary, EPA concludes that TCEQ's approach for deriving the reservoir-specific chlorophyll *a* criteria is scientifically defensible in that it is transparent, repeatable, and consistent with TCEQ's intent to maintain existing water quality and protect the long-term existing conditions in these reservoirs. However, not all of the reservoir-specific criteria are sufficient to protect the applicable designated uses as required by the *Code of Federal Regulations* (CFR) at 40 CFR §131.11(a)(1). As such, EPA is approving 39 reservoir-specific chlorophyll *a* criteria[2] and disapproving the remaining 36 reservoir-specific chlorophyll *a* criteria, as summarized in Table 1 of this TSD and discussed in detail below.

Background

Summary of Reservoir-specific Chlorophyll a Criteria for 75 Texas Reservoirs

TCEQ's 75 reservoir-specific chlorophyll *a* criteria (more specifically, the criteria magnitudes) are identified in the TX WQS at §307.10, Appendix F and are also shown in Table 2 of this TSD. The reservoir-specific criteria magnitudes range from 5.00 µg/L to 55.80 µg/L. In order to derive these criteria magnitudes, TCEQ applied the same statistical method (described in more detail below) to 75 long-term reservoir-specific chlorophyll *a* ambient monitoring datasets, resulting in 75 reservoir-specific chlorophyll *a* criteria. TCEQ has stated that its criteria are intended to maintain existing water quality and to protect the long-term existing conditions in these reservoirs. Consistent with this intent, TCEQ's criteria derivation approach results in criteria that reflect the existing, long-term average conditions in these reservoirs. Because TCEQ's criteria derivation approach uses ambient chlorophyll *a* data from selected historical timeframes and results in criteria that reflect existing, long-term average conditions (rather than reference or least-disturbed conditions), TCEQ's criteria derivation approach will be referred to as the "historical ambient period approach" throughout the remainder of this TSD.

Note that for eight of the 75 reservoirs, TCEQ's historical ambient period approach to criteria derivation produced "calculated" chlorophyll *a* criteria values less than 5.00 µg/L. For these reservoirs, TCEQ set the chlorophyll *a* criteria at a minimum default criterion of 5.00 µg/L, a level that TCEQ explains could generally be historically quantified by laboratory chemical analyses.[3]

---

[1] While these 75 chlorophyll *a* criteria are only applicable to specific monitoring sites found within each reservoir (see "Site ID" column in Table 1), these 75 criteria will be referred to as "reservoir-specific criteria" throughout the remainder of this TSD for ease of reference.

[2] As explained in EPA's action letter accompanying this TSD, EPA is approving 31 of the 39 reservoir-specific chlorophyll *a* criteria subject to the outcome of consultation with the U.S. Fish and Wildlife Service under §7(a)(2) of the Endangered Species Act. These 31 criteria are indicated with an asterisk (*) in Table 1 of this TSD.

[3] EPA's review of TCEQ's use of a 5.00 µg/L minimum default criterion for these eight reservoirs is described in the reservoir-specific summaries provided in Appendix A of this TSD.

The duration and frequency components of the reservoir-specific chlorophyll *a* criteria are only described in the TX WQS insofar as they pertain to implementation of the criteria for making use attainment decisions under CWA §305(b) and §303(d).[4] The TX WQS at §307.10, Appendix F provides that the criteria are attained "when they are not exceeded by the median of monitoring data results." The TX WQS at §307.9(e)(7) further clarifies that standards attainment must be based on the long-term median of chlorophyll *a* measurements in accordance with TCEQ's *Guidance for Assessing and Reporting Surface Water Quality in Texas,* as amended (TCEQ 2010). Though "long term" is not defined in the TX WQS, the TX WQS refer to TCEQ's guidance which provides for monitoring data collected during a 7-year period of record to be used in making use attainment decisions.[5] TX WQS at §307.9(e)(7) further states that chlorophyll *a* medians are to be compared to the chlorophyll *a* criteria magnitudes for individual reservoirs identified in Appendix F of §307.10. The data for assessment must be collected at the same sampling stations used for calculating the criteria (identified in Appendix F for each reservoir and in the "Site ID" column in Table 2 below) or from comparable stations in the main pool of the reservoir.

Summary of Designated Uses the Reservoir-specific Chlorophyll a Criteria are Intended to Protect

According to §307.7(b)(4)(E) of the TX WQS, numeric and narrative criteria to preclude excessive growth of aquatic vegetation (such as the reservoir-specific chlorophyll *a* criteria) are intended to protect multiple uses such as primary, secondary, and noncontact recreation, aquatic life, and public water supplies. Table 3 shows the recreation, aquatic life, and domestic water supply uses applicable to the 75 reservoirs for which TCEQ adopted reservoir-specific chlorophyll *a* criteria. All of these reservoirs are designated for primary contact recreation and are also designated with either exceptional or high aquatic life uses. Sixty-five of the 75 reservoirs are designated with a public water supply use. Three of the 10 reservoirs without a designated public water supply use have drinking water intakes and the remaining seven reservoirs do not have a drinking water intake.

EPA Review of Reservoir-specific Chlorophyll *a* Criteria for 75 Texas Reservoirs

Under CWA §303(c), EPA is to review and to approve or disapprove state-adopted water quality standards. This review involves a determination of whether the State has adopted criteria that protect the designated water uses (see 40 CFR §131.5 (a)(2)). Further, 40 CFR §131.11(a)(1) requires states to adopt those water quality criteria that protect the designated use and provides that such criteria must be based on sound scientific rationale. For waters with multiple use designations, 40 CFR §131.11(a)(1) also provides that the criteria shall support the most sensitive use. In establishing criteria, 40 CFR §131.11(b) provides that states should establish numerical values based on §304(a) guidance, §304(a) guidance modified to reflect site-specific conditions, or other scientifically defensible methods.

EPA has recommended to states that numeric water quality criteria for nutrients be adopted into state water quality standards. EPA believes that such standards would improve the ability to detect degradation of water quality due to excess nutrients, increase the efficiency in preventing nutrient pollution from entering aquatic ecosystems, and could accelerate the pace of water quality remediation. Chlorophyll *a*,

---

[4] Since 2002, TCEQ has published the CWA §305(b) report and §303(d) list into a document which is titled the *Integrated Report.* The §303(d) list is part of the Integrated Report. The individual documents and the combined document are referenced below, depending on the context.

[5] For example, TCEQ used a period of record from December 1, 2001 through November 30, 2008, for the 2010 Integrated Report. If necessary, TCEQ's guidance allows the most recent samples collected in the preceding three years (December 1, 1998 through November 30, 2000) to also be included, if necessary to meet minimum sample size requirements. Note that this is a rolling period of record, which shifts by two years with each successive reporting cycle. The stations TCEQ used to develop the chlorophyll *a* criteria are routinely monitored (most stations four times per year, some monthly), so it is not likely that TCEQ would need to go back more than seven years for assessing attainment of the chlorophyll *a* criteria.

the primary photosynthetic pigment in phytoplankton, is among the four water quality parameters EPA has recommended that states adopt into water quality standards. EPA recommends chlorophyll *a* as a nutrient water quality criterion because it reflects the process of nutrient uptake (i.e., photosynthesis and cell growth), which in turn implies the degree of excess nutrients available, as well as the potential for organic enrichment and/or taxonomic shifts to cause stress on valued aquatic ecosystem attributes.

As described in EPA's nutrient criteria technical guidance manuals (USEPA 2000a, 2000b), EPA recommends three types of scientifically defensible empirical approaches for setting numeric nutrient criteria: reference condition approaches, mechanistic modeling, and stressor-response analysis. While TCEQ made previous attempts to derive chlorophyll *a* criteria for reservoirs using reference condition and stressor-response approaches, the approach TCEQ ultimately used to derive the 75 reservoir-specific chlorophyll *a* criteria submitted to EPA on July 20, 2010, does not reflect EPA's three types of recommended approaches. Rather, as described in the background section above, TCEQ's historical ambient period approach to criteria derivation uses ambient chlorophyll *a* data from selected historical timeframes and results in criteria that reflect existing, long-term average conditions in these reservoirs instead of reference or least-disturbed conditions.

In reviewing the 75 reservoir-specific chlorophyll *a* criteria shown in Table 2, EPA not only evaluated whether TCEQ's approach for deriving the reservoir-specific criteria was scientifically defensible as required by 40 CFR §131.11(b), but also evaluated whether the 75 reservoir-specific chlorophyll *a* criteria are protective of the applicable designated uses (identified in Table 3), as required by 40 CFR §131.11(a)(1). These evaluations and the results of the evaluations are described in detail in the following subsections.

Scientific Defensibility of TCEQ's Criteria Derivation Approach

Ensuring that criteria are derived using a transparent, repeatable approach is a key consideration in determining whether criteria are scientifically defensible. In reviewing supporting documentation that TCEQ provided to EPA on July 7, 2011, EPA believes that TCEQ's approach (including the data, assumptions, and statistics utilized) for deriving the 75 reservoir-specific chlorophyll *a* criteria magnitudes in Table 2 is both transparent and repeatable. Additionally, EPA notes that the duration and frequency components for assessment of the reservoir-specific chlorophyll *a* criteria are consistent with TCEQ's intent to maintain existing water quality and protect the long-term existing conditions in these reservoirs, as well as with the derivation of the criteria magnitudes.

In deriving the 75 reservoir-specific chlorophyll *a* criteria magnitudes, TCEQ applied a prediction interval statistical method (described below) to 75 long-term reservoir-specific chlorophyll *a* ambient monitoring datasets. More specifically, TCEQ completed each of the steps described below for each reservoir in order to derive the reservoir-specific chlorophyll *a* criteria magnitudes.

Step 1. TCEQ compiled a reservoir-specific chlorophyll a ambient monitoring dataset.

Each dataset included chlorophyll *a* measurements collected as part of TCEQ's surface water quality monitoring (SWQM) program from selected monitoring sites within the reservoir (see "Site ID" column in Table 2 below). TCEQ required at least 30 chlorophyll *a* measurements per reservoir-specific dataset in order to derive its reservoir-specific criteria. For 51 of the reservoir-specific datasets, at least 30 chlorophyll *a* measurements were available from the period 1990-2008, so chlorophyll *a* criteria were derived using only chlorophyll *a* measurements collected between 1990 and 2008. For the remaining 24 reservoir-specific datasets, all available chlorophyll *a* measurements were used in the criteria derivation in order to secure at least 30 data points. Data may extend back to 1972 for these datasets. Chlorophyll *a* measurements that were

reported as being less than the minimum historical reporting limit were assigned a value of one-half the reporting limit for purposes of criteria derivation. Chlorophyll *a* measurements outside an interquartile range of 1.5 on a Tukey box plot were excluded as outliers and were not used in criteria derivation.

Step 2. TCEQ described the underlying distribution of the reservoir-specific dataset.

TCEQ identified the number of chlorophyll *a* measurements (i.e., samples) in the dataset and calculated the mean chlorophyll *a* concentration and standard deviation of the dataset.

Step 3. TCEQ applied a prediction interval statistical method to the reservoir-specific dataset.

A prediction interval relies on what has already been observed within a population in order to estimate, with a certain probability, the range within which future observations will fall. As such, prediction intervals include both lower and upper prediction bounds. A prediction interval bears the same relationship to a future observation that a confidence interval bears to an unobservable population parameter. In other words, prediction intervals predict the distribution of individual future points, whereas confidence intervals predict the distribution of estimates of the true population mean or other quantity of interest that cannot be observed.

Using the sample number, mean, and standard deviation determined in Step 2 (which describe the underlying data distribution for the reservoir-specific dataset), TCEQ was then able to predict (with a 99% probability) the highest possible mean chlorophyll *a* concentration that could result from a future random sample of 10 chlorophyll *a* measurements collected from the same reservoir monitoring sites, with the following statistic:

$$\hat{\tilde{y}}_m = \bar{x} + t_{(1-\alpha;n-1)}(1/m + 1/n)^{1/2} s$$

where:

n = number of samples in underlying reservoir-specific dataset
m = number of future random samples (in this case, m = 10)
$\bar{x}$ = mean chlorophyll *a* concentration from underlying reservoir-specific dataset
s = standard deviation from underlying reservoir-specific dataset
t = t distribution value
α = probability (in this case, α = .99)

Step 4. TCEQ set the reservoir-specific chlorophyll a criterion magnitude.

TCEQ set the reservoir-specific chlorophyll *a* criterion magnitude equal to the upper 99% prediction bound determined in Step 3, which represents the highest possible mean chlorophyll *a* concentration that could result from a future random sample of 10 chlorophyll *a* measurements collected from the same reservoir monitoring sites.

The prediction interval statistical method that TCEQ used to derive the 75 reservoir-specific chlorophyll *a* criteria magnitudes is considered a parametric method. Parametric methods rely on the assumption that the underlying data to which the method is being applied is normally distributed. However, ecological data, and chlorophyll *a* data in particular, are rarely distributed in a normal fashion (e.g. extreme skewness, only positive values, etc.). TCEQ's use of a parametric method in deriving the reservoir-

specific chlorophyll *a* criteria was a topic that received much debate and public comment prior to TCEQ's chlorophyll *a* criteria adoption (particularly from the Texas Parks and Wildlife Department (TPWD)).

In the July 16, 2010, *Texas Register*, TCEQ presented a summary of TPWD's public comments pertaining to TCEQ's statistical methodology and responded to TPWD's comments. Based upon TCEQ's responses to TPWD's comments and additional information TCEQ provided to EPA on February 24, 2012, EPA believes that TCEQ thoroughly evaluated the strengths and weaknesses of using a parametric versus non-parametric approach, prior to selecting their ultimate approach for criteria derivation. TCEQ's decision to use parametric statistics is justified based on the fact that the parametric prediction interval statistic used in their calculation of reservoir-specific chlorophyll *a* criteria magnitudes is robust to deviations from normality (Hahn and Meeker 1991). This insensitivity to deviations from normality can be attributed to the Central Limit Theorem. The Central Limit Theorem predicts that, in cases where sample size is not small and skewness is not too extreme, the sample mean of *n* future observations will approximate a normal distribution, thus deviations from normality in TCEQ's data do not affect the validity of using parametric prediction intervals.

Protectiveness of TCEQ's 75 Reservoir-specific Chlorophyll a Criteria

TCEQ has stated that the reservoir-specific criteria are intended to maintain existing water quality and to protect the long-term existing conditions in these reservoirs. This intention is not only reflected in the approach TCEQ used to derive the reservoir-specific chlorophyll *a* criteria magnitudes but also in TCEQ's method for implementing the criteria for CWA §305(b) and §303(d) purposes, both of which were previously described. However, according to TX WQS at §307.7(b)(4)(E), numeric and narrative criteria to preclude excessive growth of aquatic vegetation (such as the reservoir-specific chlorophyll *a* criteria) are also intended to protect multiple uses such as primary, secondary, and noncontact recreation, aquatic life, and public water supplies.

In stating that the criteria are intended to protect these multiple uses, TCEQ has effectively assumed that the existing, long-term average condition in these reservoirs (reflected in the upper prediction interval of the mean of a long-term chlorophyll *a* dataset collected over many years) is sufficient to protect these multiple uses. EPA considers this to be a critical underlying assumption that must be satisfied in order to conclude that a given reservoir-specific chlorophyll *a* criterion is protective of the reservoir's designated uses as required by 40 CFR §131.11(a)(1). As described in the subsections below, EPA relied on several sources of publicly available information to independently test TCEQ's critical underlying assumption by evaluating whether each reservoir's uses were sufficiently protected with respect to nutrient impacts during the period of time over which chlorophyll *a* data used in the criteria derivation were collected.

Where available reservoir-specific data and information demonstrate that this critical underlying assumption is not satisfied, EPA can conclude that the chlorophyll *a* criterion is not protective of the reservoir's uses as required by 40 CFR §131.11(a)(1) and, therefore, cannot approve the criterion under CWA §303(c). Because the acceptability of TCEQ's use of the historical ambient period approach will vary depending upon such reservoir-specific data and information, EPA is reviewing and acting on each reservoir-specific chlorophyll *a* criterion rather than reviewing and acting on the historical ambient period approach and resulting criteria as a whole.

To evaluate whether TCEQ's critical underlying assumption described above is satisfied for each of the 75 reservoirs for which TCEQ adopted a chlorophyll *a* criterion and, therefore, to inform EPA's conclusion regarding the protectiveness of each criterion, EPA reviewed data and information from the following information sources:

1. TCEQ Integrated Reports identifying impairments for nutrient enrichment-related indicators
2. TCEQ Integrated Reports identifying water quality "concerns" for nutrients and nutrient enrichment-related indicators
3. Treated drinking water chemical data
4. Microcystin, cyanobacteria, and chlorophyll *a* data from Texas reservoirs collected during EPA's 2007 National Lakes Assessment
5. TCEQ chlorophyll *a* trend analysis results (statistical significance of trends)
6. EPA chlorophyll *a* trend analysis results (rate of chlorophyll *a* accumulation)
7. TCEQ trophic state classification information
8. Comparison of reservoir-specific chlorophyll *a* criteria to water quality management thresholds published in the scientific literature

These information sources reviewed by EPA are described in greater detail in the subsections that follow. The reservoir-specific summaries in Appendix A of this TSD present all of the data and information gathered from all of these information sources for a given reservoir. Each reservoir-specific summary also presents the overall conclusion that EPA reached for each reservoir regarding the protectiveness of the chlorophyll *a* criterion in light of all of the data and information available for that reservoir, and the resulting EPA action based on the overall conclusion.

TCEQ Integrated Reports Identifying Impairments for Nutrient Enrichment-Related Indicators

For each of the 75 reservoirs for which TCEQ adopted reservoir-specific chlorophyll *a* criteria, EPA reviewed TCEQ's CWA §303(d) lists for the past six CWA §305(b) and §303(d) reporting cycles (2010, 2008, 2006, 2004, 2002, and 2000) to identify whether or not there were any §303(d) listings for dissolved oxygen (DO) or pH, which are nutrient enrichment-related indicators. The period of record for data assessed during the 2000 through 2010 reporting cycles is approximately December 1, 1994-November 30, 2008.[6]

As described in TCEQ's 2010 *Guidance for Assessing and Reporting Surface Water Quality in Texas*, nutrient enrichment can stimulate excessive growth of algae which can, in turn, result in unhealthy (low) levels of DO for aquatic life, as well as interfere with recreational uses of the water body and impart unpleasant taste to drinking water. Further, during periods of excess primary production, removal of carbon dioxide (a weak acid) from a lake's water column during photosynthesis and addition during respiration can cause fluctuations in pH levels. Nutrient enrichment in Texas has been typically identified for management action through the listing of water bodies for DO and/or pH, with subsequent development and implementation of total maximum daily loads (TMDLs).

Occurrences of DO and/or pH impairments in a given reservoir denote that the reservoir's aquatic life use and/or general use,[7] respectively, are not being supported during the reporting cycles in which the CWA §303(d) listings occurred. Where DO and pH listings for a given reservoir are related to nutrient enrichment and data used in TCEQ's chlorophyll *a* criteria derivation were collected during the same period of record on which the listings are based, TCEQ's chlorophyll *a* criteria may not be protective of

[6] Note that the period of record used for the 2000, 2002, and 2004 reporting cycles was only 5 years, so the 2000 period of record would have begun in approximately 1995. However, in the 2006 reporting cycle, TCEQ revised its assessment methodology to allow for use of up to ten years of monitoring data, so the period of record for the 2006 reporting cycle would have begun on December 1, 1994. The period of record is rolling and shifts by two years with each successive reporting cycle.

[7] Water quality criteria for several constituents are established in the TX WQS to safeguard general water quality, rather than for protection of one specific use. Water temperature, pH, chloride, sulfate, and total dissolved solids are the parameters protecting aquatic life, recreation, public water supply, and other beneficial uses of water resources. For the purpose of assessment, the criteria protecting these multiple uses are evaluated for attainment of a construct that TCEQ entitled "general use" (TCEQ 2010).

the reservoir's uses. Table 4 identifies the 15 reservoirs where §303(d) listings for DO and/or pH occurred during the 2000 through 2010 reporting cycles.

It is important to note that because TCEQ divides many of its reservoirs into multiple assessment units, EPA also identified the specific assessment units associated with any DO and/or pH listings and considered this information in its review, as reflected in the more detailed reservoir-specific summaries found in Appendix A. Understanding which assessment units are associated with the listings is important for determining whether the listings are occurring in a certain area of the reservoir (e.g., in a riverine arm) or whether the listings are widespread at many locations throughout the reservoir. TCEQ notes that criteria exceedances for DO and pH tend to occur more often in the upper end and in cove areas of reservoirs in East Texas, and that in these cases the criteria for DO and pH tend to be very close to, and sometimes outside of, the range of natural conditions. EPA also considered the frequency with which listings occurred (for example, noting whether listings were repeated for multiple reporting cycles or only occurred once).

TCEQ Integrated Reports Identifying Water Quality "Concerns" for Nutrients and Nutrient Enrichment-Related Indicators

For each of the 75 reservoirs for which TCEQ adopted reservoir-specific chlorophyll *a* criteria, EPA also reviewed TCEQ's CWA §305(b) reports for the 2006, 2008, and 2010 reporting cycles to determine whether or not TCEQ identified any water quality concerns for nutrient[8] or nutrient enrichment-related indicators.[9] The period of record for data assessed during the 2006 through 2010 reporting cycles was approximately December 1, 1997 – November 30, 2008, but may include data collected as far back as December 1994 to meet the minimum sample size requirement.

TCEQ assessed nutrient and chlorophyll *a* water quality data for the 2006, 2008, and 2010 reporting cycles using the "screening levels" shown in Table 5. These screening levels are the 85th percentile values from surface water quality monitoring data available for all reservoirs routinely monitored in the State. TCEQ identified a "concern" for water quality (not a §303(d) impairment listing) if the screening level was exceeded greater than 20 percent of the time using the binomial method, based on the number of exceedances for a given sample size. In addition to identifying concerns based on the nutrient and chlorophyll *a* screening levels shown in Table 5, TCEQ also identified concerns for nutrient enrichment-related indicators such as DO, pH, "harmful algal bloom/golden alga" (HAB/GA), and "fish kills" which EPA also considered in its review.

Though the screening levels shown in Table 5 are not water quality criteria, as noted in TCEQ's 2010 *Guidance for Assessing and Reporting Surface Water Quality in Texas*, they represent concentrations of nutrients and chlorophyll *a* that are "useful in identifying water quality concerns and in evaluating the causes of nonsupport of the narrative standards" and useful in identifying "areas where elevated concentrations are causes of concern."As such, where data used in TCEQ's chlorophyll *a* criteria derivation for a given reservoir were collected during the same period of record for which nutrient or nutrient enrichment-related concerns were identified, TCEQ's chlorophyll *a* criteria may not be protective of the reservoir's uses. As with the DO and pH listings above, EPA not only considered the presence or absence of concerns in its review but also considered the specific assessment units associated with any nutrient or nutrient enrichment-related concerns, as well as the frequency of these concerns, and how many nutrient or nutrient enrichment-related indicators were identified as concerns.

---

[8] In this TSD, "nutrient" means ammonia (NH3-N), nitrate (NO3-N), orthophosphorus (OP), or total phosphorus (TP).

[9] In this TSD, "nutrient enrichment-related indicator" means DO, pH, chlorophyll *a* (Chl-a), harmful algal bloom/golden alga (HAB/GA), or fish kill.

Table 6 identifies the 50 reservoirs where nutrient or nutrient enrichment-related concerns were identified during the 2006 through 2010 reporting cycles. And, for each of these reservoirs, Table 6 also summarizes which nutrient or nutrient enrichment-related indicators were a concern, how many assessment units in the reservoir were identified as having nutrient or nutrient enrichment-related concerns, and whether any of those assessment units encompassed the main pool near the dam or the entire reservoir. In addition to Table 6, each of the reservoir-specific summaries found in Appendix A provides a detailed table showing which nutrient or nutrient enrichment-related concerns were identified for the reservoir, organized by assessment unit, indicator, and reporting cycle.

Treated Drinking Water Chemical Data

EPA also reviewed supporting documentation provided by TCEQ on February 24, 2012, in which TCEQ noted that it examined treated drinking water chemical data for public drinking water systems from January 2002-May 2010 for the 21 reservoirs with reservoir-specific chlorophyll *a* criteria greater than 20 µg/L. TCEQ focused on examining data for disinfection byproducts and nitrate concentrations, as these parameters are of interest in the context of eutrophication. As described in Table 7 and in Appendix A, TCEQ noted three reservoirs having periodic occurrences of total trihalomethanes (TTHMs) or haloacetic acids (HAAs) above the Safe Drinking Water Act (SDWA) maximum contaminant level (MCL).

Microcystin, Cyanobacteria, and Chlorophyll a Data from Texas Reservoirs Collected During EPA's 2007 National Lakes Assessment

As part of EPA's 2007 National Lakes Assessment (NLA), over 1,000 lakes across the country, including 17 of the 75 reservoirs for which TCEQ adopted reservoir-specific chlorophyll *a* criteria, were sampled for their water quality, biological condition, habitat conditions, and recreational suitability (USEPA 2009). With respect to recreational suitability, NLA analysts assessed three particular indicators: 1) microcystin – a type of algal toxin that can harm humans, pets, and wildlife, 2) cyanobacteria – a type of algae that can pose a nuisance to animals and humans and are known to produce toxins, and 3) chlorophyll *a* – a measure of all algal biomass present. While EPA does not presently have recommended water quality criteria for microcystin, cyanotoxins, or any other algal toxins, the World Health Organization (WHO) has established recreational exposure guidelines for chlorophyll *a*, cyanobacterial cell counts, and microcystin (WHO 2003).[10] The WHO has also published a provisional drinking water exposure guideline for microcystin-LR, a specific form of microcystin, which is 1 µg/L (WHO 1998). The thresholds shown in Table 8, along with the presence or absence of microcystin, were used in EPA's 2007 NLA to assess the condition of lakes of the nation with respect to this indicator suite. A lake that is in good condition exhibits a low risk of exposure. Conversely, a lake in poor condition has a high risk of exposure.

Because microcystin samples from the NLA survey were collected at mid-lake and some studies indicate that cell counts and cyanotoxin concentrations are greater in nearshore scums than in open water areas, the NLA results may underestimate certain types of recreational exposure when accumulations or scums are present at nearshore areas in lakes. Additionally, chlorophyll *a* levels, cyanobacteria cell counts, and cyanotoxin concentrations may change quite rapidly, depending on bloom intensity and weather conditions at a lake. As such, the concentrations of microcystin measured on one particular day may over or underestimate season-wide central tendencies. For all of these reasons, the NLA is not intended to assess the specific condition of any given lake, but rather it provides information on the general conditions across the population of lakes. EPA considered this important aspect when reviewing the

[10] Note that the WHO guidelines for microcystin associated with low and moderate risk are different from those shown in Table 8. The WHO guidelines indicate that microcystin in the range of 2-4 µg/L is associated with low risk, while microcystin in the range of 4-20 µg/L is associated with moderate risk.

available NLA data for the 17 reservoirs with reservoir-specific chlorophyll *a* criteria, and only considered the NLA data in combination with the data and information gathered from other information sources, as described in the reservoir-specific summaries found in Appendix A. Table 9 summarizes the NLA recreational condition data available for the 17 reservoirs included in the 2007 NLA report.

TCEQ Chlorophyll a Trend Analysis Results (Statistical Significance of Trends)

For each of the 75 reservoirs for which TCEQ adopted reservoir-specific chlorophyll *a* criteria, EPA reviewed supporting documentation provided to EPA on October 7, 2011, in which TCEQ presented trend analysis results based on all available chlorophyll *a* data collected for each reservoir. Trend analysis results are important to consider because they can indicate a rise in the level of organic matter production, or eutrophication, which is a key stressor on the reservoir's designated uses and a potential sign of declining water quality.

For each of the 75 reservoirs, TCEQ presented descriptive statistics, correlations, simple linear regressions, and analysis of variance (ANOVA) results for chlorophyll *a* (as well as for total nitrogen, total phosphorus, and transparency). Using all chlorophyll *a* data available for each reservoir, increasing trends in chlorophyll *a* concentration through time were identified for all but eight reservoirs.[11] Of the remaining 67 reservoirs with increasing trends, 43 reservoirs were identified as having statistically significant increasing trends.[12] However TCEQ noted that for some reservoirs, artificial trends in the chlorophyll *a* data may have been created due to changes over time in chlorophyll *a* reporting limits or due to the fact that many of the monitoring entities in the state switched from the spectrophotometric method to the fluorometric method for the analysis of chlorophyll *a*. For these reasons, as described below, EPA examined each of the reservoir-specific datasets that TCEQ used to conduct the trend analysis in order to determine if method or reporting limit changes could have affected the statistical significance of any trend identified.

In addition to analyzing reservoir-specific trends based on all of the chlorophyll *a* data available for each reservoir, TCEQ analyzed trends for each reservoir based only on chlorophyll *a* data collected using the same method (i.e., either the spectrophotometric or fluorometric method). For seven of the 43 reservoirs originally identified as having a statistically significant increasing trend when using all available chlorophyll *a* data, neither method-specific dataset showed a statistically significant increasing trend, while 36 of the 43 reservoirs had at least one method-specific dataset showing a statistically significant increasing trend in chlorophyll *a* concentration through time. Also, three lakes (Lake Austin, Greenbelt Lake, and Lake Cisco) were not originally identified as having a statistically significant increasing trend when using all available data; however, these lakes did have statistically significant increasing trends when considering the method-specific datasets.

For the 39 reservoirs with at least one method-specific dataset showing a statistically significant increasing trend in chlorophyll *a* concentration through time, EPA further examined the method-specific datasets to determine if reporting limit changes through time could have affected the statistical significance of any increasing trends identified. Note that reporting limit changes through time could only affect the statistical significance of a trend if the underlying dataset has chlorophyll *a* measurements that were reported as being less the minimum historical reporting limit. When conducting its trend analysis, TCEQ assigned a value of one-half the reporting limit for any chlorophyll *a* measurements that were reported as being less than the minimum historical reporting limit. For nine of the 39 reservoirs, EPA

[11] The following reservoirs showed decreasing trends: Medina Lake, Canyon Lake, O.H. Ivie Reservoir, Lake Kickapoo, Choke Canyon Reservoir, Lake Sweetwater, Lake Nasworthy, and Lake Livingston. Only the decreasing trends for Canyon Lake and Lake Nasworthy were considered statistically significant based on a 95% confidence level.
[12] Statistical significance was determined using a 95% confidence level.

found that assigning values other than one-half the reporting limit (for those values reported as being less than the minimum historical reporting limit) affected the statistical significance of the chlorophyll *a* trend through time to such a degree that the trend was no longer considered statistically significant. This was particularly true in cases where the minimum historical reporting limits associated with a given dataset were higher in more recent years than they had been in the past.[13]

In summary, after considering the effect of method or reporting limit changes, 30 reservoirs were found to have a statistically significant increasing trend in chlorophyll *a* concentration through time. Table 10 summarizes the trend analysis results described above for all 75 reservoirs with reservoir-specific chlorophyll *a* criteria, with more detailed descriptions provided in the reservoir-specific summaries in Appendix A.

EPA Chlorophyll a Trend Analysis Results (Rate of Chlorophyll a Accumulation)

TCEQ's trend analysis results described above identified 67 reservoirs as having increasing trends in chlorophyll *a* concentration over time, with only 30 of these 67 reservoirs exhibiting a statistically significant increasing trend after considering the effect of method or reporting limit changes. However, there are limitations to only examining the statistical significance of these increasing trends. For example, a very small trend can be statistically significant if it was observed over many years, but it could be so small that it does not represent a large enough increase in organic matter production to substantially influence attainment of designated uses in the waterbody. Conversely, a large trend indicating a large rise in the level of organic matter production, or eutrophication, may not be statistically significant because a small number of chlorophyll *a* measurements are available. For these reasons, EPA independently evaluated TCEQ's reservoir-specific chlorophyll *a* trend datasets to determine the magnitude of the slope of the chlorophyll *a* trends, which describes the rate of chlorophyll *a* accumulation over time and serves as a representation of the level of organic matter enrichment over time.

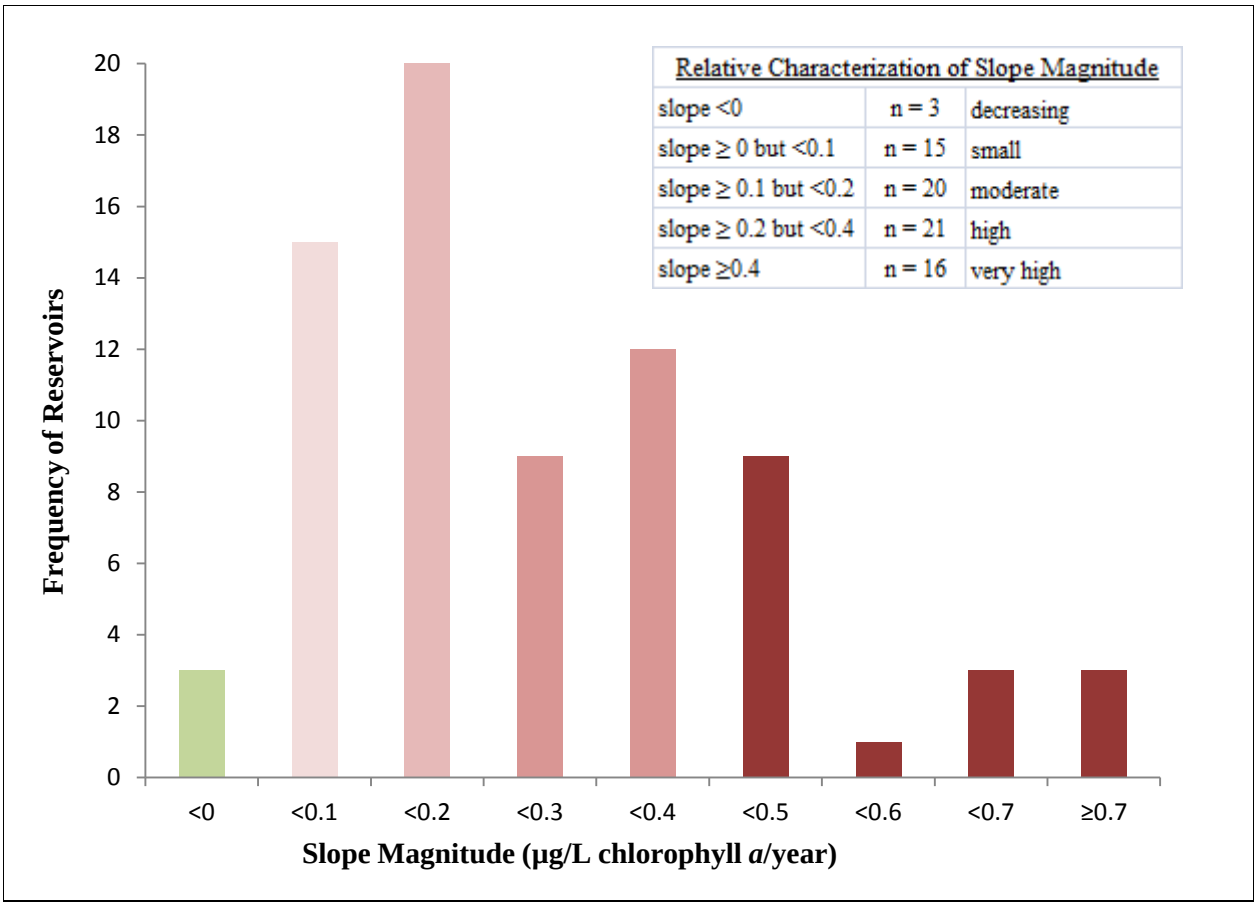
Using all the available chlorophyll *a* data included in TCEQ's reservoir-specific chlorophyll *a* trend datasets, EPA modeled the trend for each reservoir based on the annual geometric mean chlorophyll *a* concentrations calculated for each reservoir.[14] Basing each trend on the annual geometric mean chlorophyll *a* concentrations for a given reservoir addresses the fact that the distribution of chlorophyll *a* sample values is log-normally distributed, while allowing for the estimation of a long-term trend in terms of untransformed chlorophyll *a*. Examining annual geometric means also addresses those cases where the long-term trend is obscured in lakes in which many samples are collected in a few years, and other years have only a few samples. The slope magnitudes associated with each reservoir-specific trend modeled as described above are reported in units of µg/L chlorophyll *a*/year in Table 11. As shown in Figure 1 and Table 11, approximately half of the reservoir-specific trends exhibited a slope magnitude >0.2 µg/L chlorophyll *a*/year, with the highest accumulation rate being 1.55 µg/L chlorophyll *a*/year for O.C. Fisher Lake. The results of EPA's trend analysis can also be found in the reservoir-specific summaries in Appendix A.

---

[13] For example, in Stillhouse Hollow Lake, 51 chlorophyll *a* measurements were made using the spectrophotometric method, with 38 of these measurements (~75%) being reported as less than the minimum historical reporting limits. TCEQ identified a statistically significant increasing trend for this dataset when it assigned a value of one-half the reporting limit to those 38 measurements reported as being less than the minimum historical reporting limits. However, EPA found that assigning a value other than one-half the reporting limit affected the statistical significance of the chlorophyll *a* trend through time to such a degree that the trend was no longer considered statistically significant. This was particularly true in the case of Stillhouse Hollow Lake because minimum historical reporting limits were ≤4.00 µg/L before 2000 but ≤10.00 µg/L after 2000.

[14] Note that the annual geometric mean chlorophyll *a* concentrations were weighted by the number of samples used to compute each average.

Figure 1. Histogram showing the frequency of reservoirs with trends exhibiting slope magnitudes within various ranges, including a relative characterization of slope magnitudes.



TCEQ Trophic State Classification Information

For several years, TCEQ has evaluated and ranked major Texas reservoirs using Carlson's Trophic State Index (TSI) and included its findings in a report titled *Trophic Classification of Texas Reservoirs.* The latest version of this report was developed in conjunction with TCEQ's 2010 Integrated Report and provides trophic state classification data and information for 57 of the 75 reservoirs for which TCEQ adopted reservoir-specific chlorophyll *a* criteria (TCEQ 2011). In the trophic classification report, TCEQ explains the following:

> "The trophic state of a reservoir refers to its nutritional status that is indicated by measurements of nutrients and algae. Various classification schemes…or indices have been developed that group reservoirs into discrete quality (trophic) states along a continuum from oligotrophic (poorly nourished) to hypereutrophic (over nourished). The basis for the trophic state index concept is that in many reservoirs the degree of eutrophication may be related to increased nutrient concentrations."

In addition to identifying the trophic state classification for these 57 reservoirs for the 2010 reporting cycle, TCEQ's report also characterizes long-term change in trophic state classification in these reservoirs by comparing chlorophyll *a* TSI values between the 2010 and 2000 reporting cycles. TCEQ's report explains that for each reservoir, the chlorophyll *a* TSI value reported for the 2010 reporting cycle is an

average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008. The report also explains that this TSI value was then compared with the chlorophyll *a* TSI value calculated for the 2000 reporting cycle (reporting cycle of September 1, 1989 - August 31, 1999). The table beginning on page 9 of TCEQ's report identifies the difference between the chlorophyll *a* TSI values for the 2000 and 2010 reporting cycles as "10-year Change (Chla TSI)."

Using the chlorophyll *a* TSI value for the 2010 reporting cycle and the "10-year Change (Chla TSI)" value recorded for each reservoir in TCEQ's report, EPA was able to determine what the chlorophyll *a* TSI value would have been for each reservoir for the 2000 reporting cycle. Based upon this information and the TSI index range associated with each trophic class as identified on page 4 of TCEQ's report, EPA was then able to characterize the change in trophic state classification for each reservoir between the two 10-year time periods. Table 12 summarizes the trophic state classification information described above, with more detailed descriptions provided in the reservoir-specific summaries in Appendix A of this TSD.

While it is difficult to identify the point at which nutrient enrichment equates to non-support of a reservoir's designated uses, a review of the available trophic state classification information in TCEQ's report can indicate the relative degree of nutrient enrichment present in these 57 reservoirs, as well as the biological condition generally associated with the various trophic classifications. For example, TPWD included a report in its March 10, 2010, comments to TCEQ (on its proposed water quality standards rulemaking for the reservoir-specific chlorophyll *a* criteria) which contained the following statements regarding hypereutrophic reservoirs:

> "In June 2004, TPWD put forward its own recommendations for calculating reservoir nutrient criteria. TPWD noted that it could manage Texas reservoirs for multiple uses under a diversity of nutrient levels; however, it could not work effectively with a hypereutrophic situation. In hypereutrophic environments there can be a loss of diversity of fish species and a loss of sport fish populations. TPWD thus seeks to avert any situation that leads to deterioration in water quality" (TPWD 2007).

It is clear from TPWD's comments that TPWD is concerned about designated use support in hypereutrophic waters and that such conditions are to be avoided. Where data used in TCEQ's chlorophyll *a* criteria derivation for a given reservoir reflect a hypereutrophic classification or a decline in water quality resulting in a shift to a hypereutrohphic classification, the chlorophyll *a* criterion is not likely to be protective of the reservoir's designated uses.

Comparison of Reservoir-specific Chlorophyll a Criteria to Water Quality Management Thresholds Published in the Scientific Literature

For decades, scientific research has documented how excess nutrients are the principle driver of increased organic matter enrichment to aquatic ecosystems, a phenomenon known as eutrophication (NAS 1969, NRC 2000). In addition to fueling organic enrichment, excess nutrients can drive phytoplankton species composition toward numerically dominant taxa (e.g., cyanobacteria) (Lopez et al. 2008). Scientific research has shown how both biologically-driven processes act as stressors on a variety of valued aquatic ecosystem attributes such as aquatic life, aesthetics, recreation, and drinking water quality (Carlson 1977, Dodds et al. 2009, Downing et al. 2001, Elser et al. 1990, Paerl 1988, Smith 2003, Smith et al. 1999, WHO 1999). Organic enrichment can increase oxygen demand and cause respiratory stress in aquatic organisms. Organic enrichment can also interfere with source water disinfection processes causing the development of unwanted carcinogenic byproducts in finished drinking water supplies. Accumulation of phytoplankton biomass can decrease water clarity and reduce available light for submerged aquatic vegetation growth. In other instances, the disproportionate growth and accumulation of certain

phytoplankton taxa can become a nuisance for recreational swimmers or boaters, decrease the aesthetics (i.e., visual appeal and odor) of the water, or may be directly toxic to humans, animals, and aquatic life. EPA recommends chlorophyll *a* as a nutrient water quality criterion because it reflects the process of nutrient uptake (i.e., photosynthesis and cell growth), which in turn implies the degree of excess nutrients available, as well as the potential for organic enrichment and/or taxonomic shifts to cause stress on valued aquatic ecosystem attributes.

As described above, TCEQ's criteria are expressed as a long-term central tendency of a chlorophyll *a* dataset (i.e., the upper prediction interval of the mean of a long-term dataset collected over many years). The assumption TCEQ has made with each reservoir's criterion is that the estimate of the long-term mean chlorophyll *a* is sufficiently protective of the reservoir's different designated uses (e.g., recreation, aquatic life, and public water supply). However, TCEQ's criteria derivation approach has the potential to overlook individual, elevated chlorophyll *a* measurements within the same data set that may be indicative of higher risks to the designated uses. In other words, the long-term mean chlorophyll *a* condition of the reservoir may not reflect the short-term (i.e., days, weeks, months) risks to designated uses, whereas individual chlorophyll *a* concentrations may be more reflective of short-term phytoplankton bloom events on the reservoir's designated uses.

To gauge the effectiveness of a chlorophyll *a* criterion to detect water quality degradation and increased risk of harming valued aquatic ecosystem attributes due to excess nutrients, it is important to consider the effects of organic enrichment and taxonomic shifts across a magnitude, duration, and frequency gradient rather than assuming that a statistical estimate of central tendency is inherently protective of designated uses. For example, elevated risks to aquatic life and human health have been documented across a gradient of accumulated phytoplankton biomass, as indicated by instantaneous chlorophyll *a* concentrations. The risks associated with elevated phytoplankton productivity and accumulated biomass include, but are not limited to:

- Nuisance blooms (e.g., chlorophyll *a* concentrations > 30 μg/L; see Walmsley 1984, Walker 1985, Walker and Havens 1995).
- Toxic cyanobacteria and toxin production (e.g., chlorophyll *a* concentrations > 50 μg/L; see Chorus et al. 2000, WHO 2003, Bigham et al. 2009, Lindon and Heiskary 2009)
- Taste and odor compound production (Graham et al. 2010)
- Disinfection byproduct production (Huang et al. 2009)

EPA evaluated each of the chlorophyll *a* criteria and the underlying chlorophyll *a* dataset available for each reservoir[15] against chlorophyll *a* concentrations published in the scientific literature that reflect elevated risks to aquatic life and human health. While there are no universally accepted or widely applied chlorophyll *a* thresholds that indicate or predict adverse effects to aquatic life and/or human health in reservoirs, there is a large body of scientific evidence that points to chlorophyll *a* concentrations greater than 30 μg/L as a level of phytoplankton biomass that can result in nuisance algal blooms, toxic cyanobacteria and toxin production, taste and odor compound production, and generation of disinfection byproducts in finished drinking water. EPA has independently evaluated TCEQ's chlorophyll *a* data to explore the relationships between individual chlorophyll *a* concentrations and mean chlorophyll *a* concentrations (Figure 2), as well as between microcystin detection and individual chlorophyll *a* concentrations (Figure 3). These data explorations indicate the following:

[15] This means the full chlorophyll *a* dataset available for each reservoir as provided in supporting documentation that TCEQ submitted to EPA on July 7, 2011. For most reservoirs, the full chlorophyll *a* dataset available included more measurements than were included in the dataset considered for criterion derivation purposes.

- As mean chlorophyll *a* concentrations increase, the probability that an individual chlorophyll *a* concentration will exceed 30 µg/L also increases (Figure 2).
- As individual chlorophyll *a* concentrations increase, the probability of detecting microcystins also increases (Figure 3).

Figure 2. Probability of individual chlorophyll *a* concentrations greater than 30 µg/L (solid line) or 50 µg/L (dotted line) as a function of mean chlorophyll *a* concentrations across 75 Texas reservoirs. Data were compiled from all 75 reservoirs.

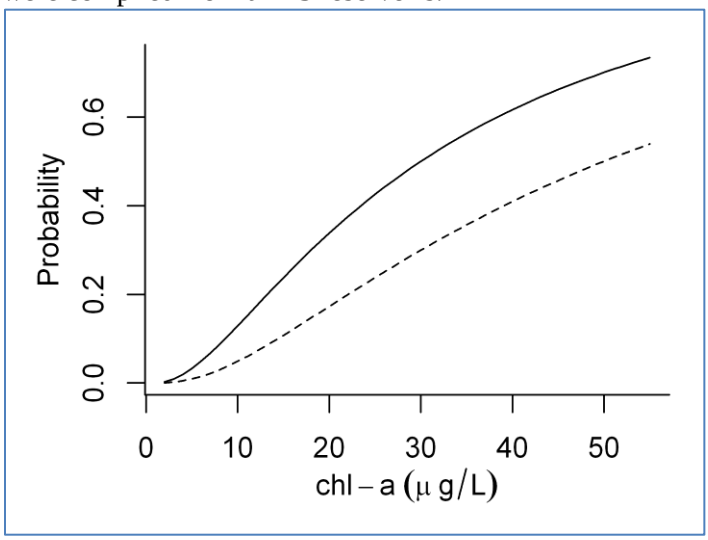


Figure 3. Probability of detecting microcystin as a function of individual chlorophyll *a* concentrations. Data were obtained from U.S. EPA's 2007 National Lake Assessment data set.

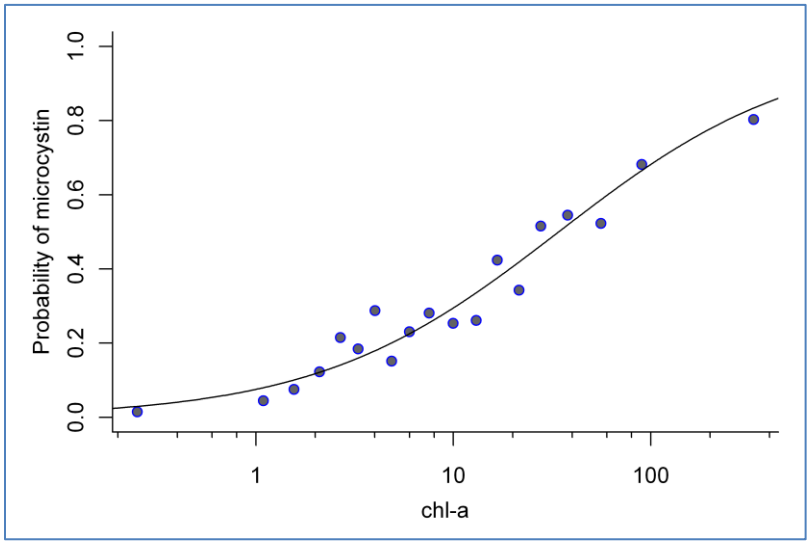


Table 13 below shows the percent of individual chlorophyll *a* measurements included in the underlying chlorophyll *a* dataset available for each reservoir[16] that are equal to or greater than 30 µg/L. When 10% or more of the individual chlorophyll *a* measurements included in the underlying chlorophyll *a* dataset available for each reservoir are equal to or greater than 30 µg/L, the chlorophyll *a* criterion is not likely to be protective of the reservoir's designated uses. In such cases, the criterion (which is derived and

[16] As provided in supporting documentation that TCEQ submitted to EPA on July 7, 2011.

expressed as a long-term central tendency), is not likely to be protective because the criterion would not protect designated uses from the effects of high instantaneous chlorophyll *a* concentrations (such as nuisance blooms, toxic cyanobacteria and toxin production, taste and odor compound production, and disinfection byproduct production). The results of EPA's evaluation can also be found in the reservoir-specific summaries in Appendix A.

Summary of EPA Actions on Reservoir-specific Chlorophyll *a* Criteria for 75 Texas Reservoirs

The critical assumption underlying TCEQ's historical ambient period approach to chlorophyll *a* criteria derivation is that the existing, long-term average condition in these reservoirs is sufficient to protect the applicable recreation, aquatic life, and domestic water supply uses in these reservoirs. EPA considers this assumption to be a critical underlying assumption that must be satisfied in order to conclude that a given reservoir-specific chlorophyll *a* criterion is protective of the reservoir's designated uses as required by 40 CFR §131.11(a)(1).

EPA relied on several sources of publicly available information (described previously in this TSD) to independently test TCEQ's critical underlying assumption by evaluating whether each reservoir's uses were sufficiently protected with respect to nutrient impacts during the period of time over which chlorophyll *a* data used in the criteria derivation were collected. Where available reservoir-specific data and information show one of the following scenarios for a given reservoir, EPA concludes in Appendix A that TCEQ's critical underlying assumption is not satisfied:[17]

1. Reservoirs where TCEQ's 2010 trophic classification report indicates a hypereutrophic classification in both the 2000 and 2010 Integrated Report cycles.
2. Reservoirs where TCEQ's 2010 trophic classification report indicates a mesotrophic or eutrophic classification in the 2000 Integrated Report cycle with a shift to a hypereutrophic classification in the 2010 Integrated Report cycle.
3. Reservoirs where 10% or more of the individual chlorophyll *a* measurements included in the underlying chlorophyll *a* dataset available for each reservoir are equal to or greater than 30 µg/L.
4. Reservoirs where the magnitude of the slope of the trend determined from EPA's trend analysis using TCEQ's chlorophyll *a* data was equal to or greater than 0.1 µg/L but less than 0.2 µg/L chlorophyll *a*/ year (i.e., relatively moderate accumulation rate), and TCEQ identified five or more nutrient concerns in the 2006 through 2010 Integrated Report cycles that are repeating.[18]
5. Reservoirs where the magnitude of the slope of the trend determined from EPA's trend analysis using TCEQ's chlorophyll *a* data was equal to or greater than 0.2 µg/L chlorophyll *a*/year (i.e., relatively high or very high accumulation rate), and TCEQ identified three or more nutrient concerns in the 2006 through 2010 Integrated Report cycles that are repeating.

Where reservoir-specific data and information show one of the five scenarios described above, reservoir-specific information available from the other information sources examined generally corroborates that

[17] Note that there are two reservoirs (Oak Creek Reservoir and Lake Stamford) which showed Scenario 2, but which, for reasons described in Appendix A, EPA is not disapproving the reservoir-specific chlorophyll *a* criteria.
[18] One concern is any nutrient/assessment unit/Integrated Report year combination. "Nutrient" means ammonia, nitrate, orthophosphorus, or total phosphorus. "Repeating" means either (1) two or more nutrient/assessment unit combinations are repeated in two Integrated Report cycles or (2) at least one nutrient/assessment unit combination is repeated in three Integrated Report cycles.

TCEQ's critical underlying assumption is not satisfied. For those reservoirs where EPA concludes that the critical underlying assumption is not satisfied, EPA concludes in Appendix A that the chlorophyll *a* criterion is not protective of the reservoir's uses as required by 40 CFR § 131.11(a)(1) and is, therefore, disapproving the reservoir-specific chlorophyll *a* criterion. Table 1 summarizes EPA's decisions under CWA §303(c) to approve or disapprove each of the 75 reservoir-specific chlorophyll *a* criteria adopted by TCEQ.

The reservoir-specific summaries in Appendix A of this TSD present all of the data and information gathered from all of the information sources described in this TSD for a given reservoir. Each reservoir-specific summary also presents the overall conclusion that EPA reached for each reservoir regarding the protectiveness of the chlorophyll *a* criterion in light of all of the data and information available for that reservoir, as well as the resulting EPA action based on the overall conclusion.

Table 14 of this TSD provides a "snapshot" overview of all the data and information gathered from all of the information sources described in this TSD for all 75 reservoirs, as well as EPA's decisions under CWA §303(c) to approve or disapprove each of the 75 reservoir-specific chlorophyll *a* criteria.

Tables

Table 1. Summary of EPA's decisions under CWA § 303(c) to approve or disapprove each of the 75 reservoir-specific chlorophyll *a* criteria adopted by TCEQ: 39 approvals and 36 disapprovals.

Reservoir Number	Reservoir Name	Segment ID	Site ID	Chlorophyll *a* Criterion (µg/L)	EPA Action[1]
1	Stillhouse Hollow Lake	1216	11894	5.00	Approved*
2	Medina Lake	1904	12826	5.00	Approved*
3	Lake Austin	1403	12294	5.00	Approved*
4	Lake Travis	1404	12302	5.00	Approved*
5	Lake Georgetown	1249	12111	5.00	Approved*
6	Canyon Lake	1805	12597	5.00	Approved*
7	Greenbelt Lake	0223	10173	5.00	Approved*
8	Lake Cisco	1234	12005	5.00	Approved*
9	Bridgeport Reservoir	0811	10970	5.32	Approved*
10	Lake Jacksonville	0614	10639	5.60	Approved
11	Hubbard Creek Reservoir	1233	12002	5.61	Approved*
12	O.H. Ivie Reservoir	1433	12511	5.77	Approved*
13	Lake Graham	1231	11979	6.07	Approved*
14	Lake Coleman	1419	12398	6.07	Approved*
15	Lake Kickapoo	0213	10143	6.13	Approved*
16	Sam Rayburn Reservoir	0610	14906	6.22	Approved
17	Belton Lake	1220	11921	6.38	Approved*
18	Oak Creek Reservoir	1426	12180	6.93	Approved
19	Lake Crook	0208	10137	7.38	Approved*
20	Lady Bird Lake (Town Lake)	1429	12476	7.56	Approved*
21	Lake Cherokee	0510	10445	8.25	Approved*
22	Lake Kemp	0217	10159	8.83	Approved*
23	Lake Buchanan	1408	12344	9.82	Approved*
24	Lake Lyndon B. Johnson	1406	12324	10.29	Approved*
25	Marble Falls Lake	1405	12319	10.48	Approved*
26	Possum Kingdom Lake	1207	11865	10.74	Approved*
27	Lake Tyler East	0613	10638	10.88	Approved
28	Houston County Lake	0813	10973	11.10	Approved
29	Lake Arrowhead	0212	10142	11.21	Disapproved
30	B. A. Steinhagen Lake	0603	10582	11.67	Approved
31	Granger Lake	1247	12095	11.72	Disapproved
32	Grapevine Lake	0826	11035, 16113, 17827	11.90	Disapproved
33	Choke Canyon Reservoir	2116	13019	12.05	Approved*
34	Pat Mayse Lake	0209	10138	12.40	Approved*
35	Lake Sweetwater	1237	12021	13.28	Disapproved
36	Lake Tyler	0613	10637	13.38	Approved
37	Cox Lake	2454	12514	13.56	Disapproved
38	White River Lake	1240	12027	13.85	Approved*
39	Aquilla Reservoir	1254	12127	14.10	Disapproved
40	Twin Buttes Reservoir	1423	12422	14.44	Disapproved
41	Lake Fork Reservoir	0512	10458	14.50	Disapproved
42	Navarro Mills Lake	0817	10981	15.07	Approved*
43	Richland-Chambers Reservoir	0836	15168	15.29	Disapproved

[1] As explained in EPA's action letter accompanying this TSD, EPA is approving 31 of the 39 reservoir-specific chlorophyll *a* criteria subject to the outcome of consultation with the U.S. Fish and Wildlife Service under §7(a)(2) of the Endangered Species Act. These 31 criteria are indicated with an asterisk (*) in Table 1 of this TSD.

Reservoir Number	Reservoir Name	Segment ID	Site ID	Chlorophyll *a* Criterion (µg/L)	EPA Action[1]
44	Lake Colorado City	1412	12167	15.60	Disapproved
45	Millers Creek Reservoir	1208	11679	15.65	Disapproved
46	Lake Stamford	1235	12006	16.85	Approved*
47	Lake Nasworthy	1422	12418	16.91	Approved*
48	Lake Corpus Christi	2103	12967	17.17	Disapproved
49	Lake Cypress Springs	0405	10312	17.54	Approved
50	Whitney Lake	1203	11851	18.34	Disapproved
51	Lewisville Lake	0823	11027	18.45	Disapproved
52	Lake Pat Cleburne	1228	11974	19.04	Approved*
53	Lake Limestone	1252	12123	19.26	Disapproved
54	Lake Waxahachie	0816	10980	19.77	Approved*
55	Wright Patman Lake	0302	10213	21.49	Disapproved
56	Palo Duro Reservoir	0100	10005	21.73	Disapproved
57	Lake Granbury	1205	11860	22.16	Disapproved
58	Bardwell Reservoir	0815	10979	22.84	Disapproved
59	Lake Livingston	0803	10899	22.96	Disapproved
60	Waco Lake	1225	11942	23.16	Disapproved
61	Brady Creek Reservoir	1416	12179	24.15	Disapproved
62	Lake Conroe	1012	11342	24.27	Disapproved
63	Red Bluff Reservoir	2312	13267	25.14	Disapproved
64	Eagle Mountain Reservoir	0809	10944, 10945	25.37	Disapproved
65	Benbrook Lake	0830	15151, 11046	27.15	Disapproved
66	Lake Palestine	0605	16159	27.34	Disapproved
67	Proctor Lake	1222	11935	28.15	Disapproved
68	Cedar Creek Reservoir	0818	10982, 16749	30.40	Disapproved
69	White Rock Lake	0827	11038	33.65	Disapproved
70	Lake Worth	0807	10942	34.18	Disapproved
71	Lake Tawakoni	0507	10434	37.18	Disapproved
72	O.C. Fisher Lake	1425	12429	39.13	Disapproved
73	Lake Tanglewood	0229	10192	43.71	Disapproved
74	Somerville Lake	1212	11881	53.05	Disapproved
75	Murval Lake	0509	10444	55.80	Disapproved

Table 2. Reservoir-specific chlorophyll *a* criteria adopted for 75 Texas reservoirs.

Reservoir Number	Reservoir Name	Segment ID	Site ID	Chlorophyll *a* Criterion (µg/L)	"Calculated" Value (µg/L)
1	Stillhouse Hollow Lake	1216	11894	5.00	2.07
2	Medina Lake	1904	12826	5.00	2.15
3	Lake Austin	1403	12294	5.00	3.58
4	Lake Travis	1404	12302	5.00	3.66
5	Lake Georgetown	1249	12111	5.00	3.87
6	Canyon Lake	1805	12597	5.00	4.11
7	Greenbelt Lake	0223	10173	5.00	4.59
8	Lake Cisco	1234	12005	5.00	4.64
9	Bridgeport Reservoir	0811	10970	5.32	
10	Lake Jacksonville	0614	10639	5.60	
11	Hubbard Creek Reservoir	1233	12002	5.61	
12	O.H. Ivie Reservoir	1433	12511	5.77	
13	Lake Graham	1231	11979	6.07	
14	Lake Coleman	1419	12398	6.07	
15	Lake Kickapoo	0213	10143	6.13	
16	Sam Rayburn Reservoir	0610	14906	6.22	
17	Belton Lake	1220	11921	6.38	
18	Oak Creek Reservoir	1426	12180	6.93	
19	Lake Crook	0208	10137	7.38	
20	Lady Bird Lake (Town Lake)	1429	12476	7.56	
21	Lake Cherokee	0510	10445	8.25	
22	Lake Kemp	0217	10159	8.83	
23	Lake Buchanan	1408	12344	9.82	
24	Lake Lyndon B. Johnson	1406	12324	10.29	
25	Marble Falls Lake	1405	12319	10.48	
26	Possum Kingdom Lake	1207	11865	10.74	
27	Lake Tyler East	0613	10638	10.88	
28	Houston County Lake	0813	10973	11.10	
29	Lake Arrowhead	0212	10142	11.21	
30	B. A. Steinhagen Lake	0603	10582	11.67	
31	Granger Lake	1247	12095	11.72	
32	Grapevine Lake	0826	11035, 16113, 17827	11.90	
33	Choke Canyon Reservoir	2116	13019	12.05	
34	Pat Mayse Lake	0209	10138	12.40	
35	Lake Sweetwater	1237	12021	13.28	
36	Lake Tyler	0613	10637	13.38	
37	Cox Lake	2454	12514	13.56	
38	White River Lake	1240	12027	13.85	
39	Aquilla Reservoir	1254	12127	14.10	
40	Twin Buttes Reservoir	1423	12422	14.44	
41	Lake Fork Reservoir	0512	10458	14.50	
42	Navarro Mills Lake	0817	10981	15.07	
43	Richland-Chambers Reservoir	0836	15168	15.29	
44	Lake Colorado City	1412	12167	15.60	
45	Millers Creek Reservoir	1208	11679	15.65	
46	Lake Stamford	1235	12006	16.85	
47	Lake Nasworthy	1422	12418	16.91	
48	Lake Corpus Christi	2103	12967	17.17	

Reservoir Number	Reservoir Name	Segment ID	Site ID	Chlorophyll *a* Criterion (µg/L)	"Calculated" Value (µg/L)
49	Lake Cypress Springs	0405	10312	17.54	
50	Whitney Lake	1203	11851	18.34	
51	Lewisville Lake	0823	11027	18.45	
52	Lake Pat Cleburne	1228	11974	19.04	
53	Lake Limestone	1252	12123	19.26	
54	Lake Waxahachie	0816	10980	19.77	
55	Wright Patman Lake	0302	10213	21.49	
56	Palo Duro Reservoir	0100	10005	21.73	
57	Lake Granbury	1205	11860	22.16	
58	Bardwell Reservoir	0815	10979	22.84	
59	Lake Livingston	0803	10899	22.96	
60	Waco Lake	1225	11942	23.16	
61	Brady Creek Reservoir	1416	12179	24.15	
62	Lake Conroe	1012	11342	24.27	
63	Red Bluff Reservoir	2312	13267	25.14	
64	Eagle Mountain Reservoir	0809	10944, 10945	25.37	
65	Benbrook Lake	0830	15151, 11046	27.15	
66	Lake Palestine	0605	16159	27.34	
67	Proctor Lake	1222	11935	28.15	
68	Cedar Creek Reservoir	0818	10982, 16749	30.40	
69	White Rock Lake	0827	11038	33.65	
70	Lake Worth	0807	10942	34.18	
71	Lake Tawakoni	0507	10434	37.18	
72	O.C. Fisher Lake	1425	12429	39.13	
73	Lake Tanglewood	0229	10192	43.71	
74	Somerville Lake	1212	11881	53.05	
75	Murval Lake	0509	10444	55.80	

Table 3. Uses applicable to the 75 Texas reservoirs with reservoir-specific chlorophyll *a* criteria.

Reservoir Number	Reservoir Name	Segment ID	Classified or Unclassified	Recreation Use[1]	Aquatic Life Use[2]	Domestic Water Supply[3]
1	Stillhouse Hollow Lake	1216	classified	PCR	E	PS, SS
2	Medina Lake	1904	classified	PCR	H	PS, AP
3	Lake Austin	1403	classified	PCR	H	PS, SS
4	Lake Travis	1404	classified	PCR	E	PS, SS
5	Lake Georgetown	1249	classified	PCR	H	PS, AP
6	Canyon Lake	1805	classified	PCR	E	PS, SS, AP
7	Greenbelt Lake	0223	classified	PCR	H	PS, SS
8	Lake Cisco	1234	classified	PCR	H	PS, SS
9	Bridgeport Reservoir	0811	classified	PCR	H	PS, SS
10	Lake Jacksonville	0614	classified	PCR	H	PS
11	Hubbard Creek Reservoir	1233	classified	PCR	H	PS, SS
12	O.H. Ivie Reservoir	1433	classified	PCR	H	PS, SS
13	Lake Graham	1231	classified	PCR	H	PS
14	Lake Coleman	1419	classified	PCR	H	PS, SS
15	Lake Kickapoo	0213	classified	PCR	H	PS
16	Sam Rayburn Reservoir	0610	classified	PCR	H	PS
17	Belton Lake	1220	classified	PCR	H	PS, SS
18	Oak Creek Reservoir	1426	unclassified	Presumed PCR	Presumed H	Two Intakes
19	Lake Crook	0208	classified	PCR	H	PS
20	Lady Bird Lake (Town Lake)	1429	classified	PCR	H	PS
21	Lake Cherokee	0510	classified	PCR	H	PS
22	Lake Kemp	0217	classified	PCR	H	No Intakes
23	Lake Buchanan	1408	classified	PCR	H	PS, SS
24	Lake Lyndon B. Johnson	1406	classified	PCR	H	PS, SS
25	Marble Falls Lake	1405	classified	PCR	H	PS, SS
26	Possum Kingdom Lake	1207	classified	PCR	H	PS, SS
27	Lake Tyler East	0613	classified	PCR	H	PS
28	Houston County Lake	0813	classified	PCR	H	PS, SS
29	Lake Arrowhead	0212	classified	PCR	H	PS, SS
30	B. A. Steinhagen Lake	0603	classified	PCR	H	PS
31	Granger Lake	1247	classified	PCR	H	PS, SS
32	Grapevine Lake	0826	classified	PCR	H	PS
33	Choke Canyon Reservoir	2116	classified	PCR	H	PS
34	Pat Mayse Lake	0209	classified	PCR	H	PS
35	Lake Sweetwater	1237	classified	PCR	H	PS
36	Lake Tyler	0613	classified	PCR	H	PS
37	Cox Lake	2454	unclassified	Presumed PCR	Presumed H	No Intakes
38	White River Lake	1240	classified	PCR	H	PS
39	Aquilla Reservoir	1254	classified	PCR	H	PS, SS
40	Twin Buttes Reservoir	1423	classified	PCR	H	PS
41	Lake Fork Reservoir	0512	classified	PCR	H	PS, SS
42	Navarro Mills Lake	0817	classified	PCR	H	PS

[1] PCR means "Primary Contact Recreation"
[2] H means "High"; E means "Excellent"
[3] PS means "Public Water Supply"; SS means "Sole Source"; AP means "Aquifer Protection"

Reservoir Number	Reservoir Name	Segment ID	Classified or Unclassified	Recreation Use[1]	Aquatic Life Use[2]	Domestic Water Supply[3]
43	Richland-Chambers Reservoir	0836	classified	PCR	H	PS, SS
44	Lake Colorado City	1412	unclassified	Presumed PCR	Presumed H	No Intakes
45	Millers Creek Reservoir	1208	unclassified	Presumed PCR	Presumed H	One Intake
46	Lake Stamford	1235	classified	PCR	H	PS, SS
47	Lake Nasworthy	1422	classified	PCR	H	PS
48	Lake Corpus Christi	2103	classified	PCR	H	PS, SS
49	Lake Cypress Springs	0405	classified	PCR	H	PS, SS
50	Whitney Lake	1203	classified	PCR	H	PS
51	Lewisville Lake	0823	classified	PCR	H	PS
52	Lake Pat Cleburne	1228	classified	PCR	H	PS
53	Lake Limestone	1252	classified	PCR	H	PS, SS
54	Lake Waxahachie	0816	classified	PCR	H	PS, SS
55	Wright Patman Lake	0302	classified	PCR	H	PS, SS
56	Palo Duro Reservoir	0100	unclassified	Presumed PCR	Presumed H	No Intakes
57	Lake Granbury	1205	classified	PCR	H	PS
58	Bardwell Reservoir	0815	classified	PCR	H	PS, SS
59	Lake Livingston	0803	classified	PCR	H	PS, SS
60	Waco Lake	1225	classified	PCR	H	PS, SS
61	Brady Creek Reservoir	1416	unclassified	Presumed PCR	Presumed H	One Intake
62	Lake Conroe	1012	classified	PCR	H	PS
63	Red Bluff Reservoir	2312	classified	PCR	H	No Intakes
64	Eagle Mountain Reservoir	0809	classified	PCR	H	PS, SS
65	Benbrook Lake	0830	classified	PCR	H	PS
66	Lake Palestine	0605	classified	PCR	H	PS, SS
67	Proctor Lake	1222	classified	PCR	H	PS, SS
68	Cedar Creek Reservoir	0818	classified	PCR	H	PS, SS
69	White Rock Lake	0827	classified	PCR	H	No Intakes
70	Lake Worth	0807	classified	PCR	H	PS, SS
71	Lake Tawakoni	0507	classified	PCR	H	PS, SS
72	O.C. Fisher Lake	1425	classified	PCR	H	PS
73	Lake Tanglewood	0229	unclassified	Presumed PCR	Presumed H	No Intakes
74	Somerville Lake	1212	classified	PCR	H	PS, SS
75	Murval Lake	0509	classified	PCR	H	PS

Table 4. Fifteen reservoirs with DO and/or pH 303(d) listings during the 2000 through 2010 reporting cycles.

Reservoir Number	Reservoir Name	Segment ID	Chlorophyll *a* Criterion (µg/L)	Reporting Cycles DO Listed	Reporting Cycles pH Listed
3	Lake Austin	1403	5.00	2000	
16	Sam Rayburn Reservoir	0610	6.22	2000-2006	2000
27	Lake Tyler East	0613	10.88		2000-2002
33	Choke Canyon Reservoir	2116	12.05	2006-2010	
39	Aquilla Reservoir	1254	14.10	2000-2004	
43	Richland-Chambers Reservoir	0836	15.29		2002-2004
49	Lake Cypress Springs	0405	17.54	2006-2008	
55	Wright Patman Lake	0302	21.49	2000-2010	2000-2010
56	Palo Duro Reservoir	0100	21.73	2000-2008	
59	Lake Livingston	0803	22.96	2000-2006	2000-2004, 2008-2010
66	Lake Palestine	0605	27.34		2006-2010
67	Proctor Lake	1222	28.15	2000-2004	
68	Cedar Creek Reservoir	0818	30.40		2002-2010
71	Lake Tawakoni	0507	37.18	2000-2004	2000, 2008-2010
74	Somerville Lake	1212	53.05	2008-2010	2002-2010

Table 5. Screening levels TCEQ used in the 2006 through 2010 reporting cycles to identify water quality concerns for nutrients and chlorophyll *a*.

Parameter	Screening Level
Ammonia (NH3-N)	0.11 mg/L
Nitrate (NO3-N)	0.37 mg/L
Orthophosphorus (OP)	0.05 mg/L
Total phosphorus (TP)	0.20 mg/L
Chlorophyll *a* (Chl-a)	26.7 µg/L

Table 6. Fifty reservoirs where nutrient or nutrient enrichment-related concerns were identified during the 2006 through 2010 reporting cycles.

Reservoir Number	Reservoir Name	Segment ID	Chlorophyll *a* Criterion (µg/L)	Reporting Cycles TCEQ Identified Nutrient or Nutrient Enrichment-Related Concerns	Nutrient or Nutrient Enrichment-Related Indicators Identified as a Concern[1]	Number of Assessment Units with Identified Nutrient or Nutrient Enrichment-Related Concerns	Did Any of These Assessment Units Encompass the Main Pool Near the Dam (Yes/No) or the Entire Reservoir (Entire)?
4	Lake Travis	1404	5.00	2006-2010	DO	5	No
6	Canyon Lake	1805	5.00	2006-2008	NO3-N, OP	3	Yes
11	Hubbard Creek Reservoir	1233	5.61	2008	DO	1	No
16	Sam Rayburn Reservoir	0610	6.22	2006-2010	NH3-N, NO3-N	7	Yes
17	Belton Lake	1220	6.38	2006-2010	Fish Kill, NO3-N	3	Yes
20	Lady Bird Lake (Town Lake)	1429	7.56	2006-2010	NO3-N	1	Yes
21	Lake Cherokee	0510	8.25	2006-2010	DO, OP, pH	2	Yes
23	Lake Buchanan	1408	9.82	2006-2010	Chl-a	1	No
24	Lake Lyndon B. Johnson	1406	10.29	2006-2010	DO	2	Yes
29	Lake Arrowhead	0212	11.21	2006-2010	OP, TP	1	Entire
31	Granger Lake	1247	11.72	2006-2010	NO3-N	3	Yes
32	Grapevine Lake	0826	11.90	2006-2010	NO3-N	4	Yes
33	Choke Canyon Reservoir	2116	12.05	2006-2010	DO	2	No
34	Pat Mayse Lake	0209	12.40	2010	Chl-a	1	No
37	Cox Lake	2454	13.56	2006-2010	Chl-a, NO3-N, OP, TP	1	Entire
39	Aquilla Reservoir	1254	14.10	2006-2010	NO3-N	3	Yes
40	Twin Buttes Reservoir	1423	14.44	2006-2010	NO3-N, OP	2	Yes
41	Lake Fork Reservoir	0512	14.50	2008-2010	Chl-a, OP	2	No
42	Navarro Mills Lake	0817	15.07	2006-2010	NO3-N	1	Entire

[1] Note that the nutrient or nutrient enrichment-related indicators identified in Table 6 are those which were identified as a concern at least once sometime during the 2006 through 2010 reporting cycles, and were not necessarily identified as a concern in multiple reporting cycles. Likewise, the number of assessment units identified in Table 6 reflects the total number of individual assessment units in the reservoir with identified nutrient or nutrient enrichment-related concerns during the 2006 through 2010 reporting cycles, and does not speak to the relationship between assessment units, indicators, and reporting cycles. Such level of detail is available in the reservoir-specific summaries in Appendix A of this TSD.

Reservoir Number	Reservoir Name	Segment ID	Chlorophyll *a* Criterion (µg/L)	Reporting Cycles TCEQ Identified Nutrient or Nutrient Enrichment-Related Concerns	Nutrient or Nutrient Enrichment-Related Indicators Identified as a Concern[1]	Number of Assessment Units with Identified Nutrient or Nutrient Enrichment-Related Concerns	Did Any of These Assessment Units Encompass the Main Pool Near the Dam (Yes/No) or the Entire Reservoir (Entire)?
43	Richland-Chambers Reservoir	0836	15.29	2006-2010	Chl-a, DO, TP	5	Yes
44	Lake Colorado City	1412	15.60	2006-2010	Chl-a, HAB/GA	1	Entire
45	Millers Creek Reservoir	1208	15.65	2006-2010	DO	1	Entire
46	Lake Stamford	1235	16.85	2008	DO	1	Entire
47	Lake Nasworthy	1422	16.91	2010	OP	1	No
48	Lake Corpus Christi	2103	17.17	2006-2010	Chl-a, DO, OP, TP	4	Yes
49	Lake Cypress Springs	0405	17.54	2006-2010	DO, NH3-N, NO3-N pH	2	No
50	Whitney Lake	1203	18.34	2006-2010	Chl-a, DO, NO3-N	4	Yes
51	Lewisville Lake	0823	18.45	2006-2010	NH3-N, NO3-N, OP, TP	2	No
52	Lake Pat Cleburne	1228	19.04	2010	Chl-a	1	Entire
53	Lake Limestone	1252	19.26	2006-2010	Chl-a, DO, NO3-N	4	Yes
55	Wright Patman Lake	0302	21.49	2006-2010	Chl-a, NH3-N, OP, pH, TP	6	Yes
56	Palo Duro Reservoir	0100	21.73	2006-2010	NH3-N, OP, TP	1	Entire
57	Lake Granbury	1205	22.16	2010	Chl-a	3	Yes
58	Bardwell Reservoir	0815	22.84	2006-2010	NO3	1	Entire
59	Lake Livingston	0803	22.96	2006-2010	Chl-a, DO, NO3-N, OP, pH, TP	9	Yes
60	Waco Lake	1225	23.16	2006-2010	Chl-a, NO3-N	3	Yes
62	Lake Conroe	1012	24.27	2008-2010	Chl-a	6	Yes
63	Red Bluff Reservoir	2312	25.14	2006-2010	Chl-a, DO, HAB/GA, NH3-N, NO3-N, OP	2	Yes

Reservoir Number	Reservoir Name	Segment ID	Chlorophyll *a* Criterion (µg/L)	Reporting Cycles TCEQ Identified Nutrient or Nutrient Enrichment-Related Concerns	Nutrient or Nutrient Enrichment-Related Indicators Identified as a Concern[1]	Number of Assessment Units with Identified Nutrient or Nutrient Enrichment-Related Concerns	Did Any of These Assessment Units Encompass the Main Pool Near the Dam (Yes/No) or the Entire Reservoir (Entire)?
64	Eagle Mountain Reservoir	0809	25.37	2006-2010	Chl-a, DO, NH3-N	8	Yes
65	Benbrook Lake	0830	27.15	2006-2010	Chl-a, NH3-N	4	Yes
66	Lake Palestine	0605	27.34	2006-2010	Chl-a, DO, NH3-N, NO3-N, OP, pH, TP	10	Yes
67	Proctor Lake	1222	28.15	2006-2010	Chl-a, TP	3	Yes
68	Cedar Creek Reservoir	0818	30.40	2006-2010	Chl-a, DO, NH3-N, NO3-N, OP, TP	11	Yes
69	White Rock Lake	0827	33.65	2010	NO3-N	1	No
70	Lake Worth	0807	34.18	2006-2008	Chl-a	1	Entire
71	Lake Tawakoni	0507	37.18	2006-2010	Chl-a, DO, OP	6	Yes
72	O.C. Fisher Lake	1425	39.13	2006-2010	Chl-a, DO, NH3-N, NO3-N,OP, TP	1	Entire
73	Lake Tanglewood	0229	43.71	2006-2010	Chl-a, DO, NH3-N, NO3-N, OP, TP	1	Entire
74	Somerville Lake	1212	53.05	2006-2010	Chl-a, DO, HAB/GA	4	Yes
75	Murval Lake	0509	55.80	2006-2010	Chl-a, OP	1	Entire

Table 7. Three reservoirs noted by TCEQ as having MCL exceedances for TTHMs or HAAs.

Reservoir Number	Reservoir Name	Segment ID	Chlorophyll *a* Criterion (µg/L)	MCL Exceedances for TTHMs or HAAs?
61	Brady Creek Reservoir	1416	24.15	TTHMs
68	Cedar Creek Reservoir	0818	30.40	HAAs
71	Lake Tawakoni	0507	37.18	HAAs

Table 8. Thresholds used in EPA's 2007 National Lakes Assessment to assess the condition of the nation's lakes with respect to chlorophyll *a*, cyanobacterial cell counts, and microcystin.

Indicator (units)	Low Risk of Exposure	Moderate Risk of Exposure	High Risk of Exposure
Chlorophyll *a* (µg/L)	< 10	10 - < 50	> 50
Cyanobacteria cell counts (#/L)	< 20,000	20,000 - < 100,000	≥ 100,000
Microcystin (µg/L)	< 10	10 - ≤ 20	> 20

Table 9. Summary of recreational condition data available from the 2007 National Lakes Assessment for 17 of the 75 reservoirs for which TCEQ adopted reservoir-specific chlorophyll *a* criteria.

Reservoir Number	Reservoir Name	Segment ID	Chlorophyll *a* Criterion (µg/L)	Chlorophyll *a*		Microcystin			Cyanobacteria	
				Concen-tration (µg/L)	Risk[1]	Concen-tration (µg/L)	Presence/ Absence	Risk	Cell Count (#/mL)	Risk
1	Stillhouse Hollow Lake	1216	5.00	3.89	Low	0.05[2]	< RL[3]	Low	< 20,000	Low
8	Lake Cisco	1234	5.00	3.63	Low	0.05	< RL	Low	< 20,000	Low
10	Lake Jacksonville	0614	5.60	8.43	Low	0.05	< RL	Low	< 20,000	Low
14	Lake Coleman	1419	6.07	4.72	Low	0.05	< RL	Low	< 20,000	Low
16	Sam Rayburn Reservoir	0610	6.22	9.6	Low	0.05	< RL	Low	20,000-100,000	Moderate
22	Lake Kemp	0217	8.83	6	Low	0.05	< RL	Low	< 20,000	Low
33	Choke Canyon Reservoir	2116	12.05	15.12	Moderate	0.05	< RL	Low	< 20,000	Low
45	Millers Creek Reservoir	1208	15.65	22.25	Moderate	0.05	< RL	Low	< 20,000	Low
45	Millers Creek Reservoir	1208	15.65	5.83	Low	0.05	< RL	Low	> 100,000	High
50	Whitney Lake	1203	18.34	No Data	No Data	0.05	< RL	Low	20,000-100,000	Moderate
51	Lewisville Lake	0823	18.45	30.24	Moderate	0.05	< RL	Low	< 20,000	Low
55	Wright Patman Lake	0302	21.49	80.1	High	0.05	< RL	Low	20,000-100,000	Moderate
59	Lake Livingston	0803	22.96	20.64	Moderate	0.05	< RL	Low	< 20,000	Low
66	Lake Palestine	0605	27.34	44.15	Moderate	0.26	Present	Low	< 20,000	Low
66	Lake Palestine	0605	27.34	25.4	Moderate	0.2	Present	Low	20,000-100,000	Moderate
69	White Rock Lake	0827	33.65	41.76	Moderate	0.21	Present	Low	< 20,000	Low
72	O.C. Fisher Lake	1425	39.13	12.58	Moderate	0.05	< RL	Low	20,000-100,000	Moderate
74	Somerville Lake	1212	53.05	50.26	High	0.05	< RL	Low	20,000-100,000	Moderate
75	Murval Lake	0509	55.80	109.83	High	0.05	< RL	Low	> 100,000	High

[1] All information in the risk columns in Table 9 are based on the thresholds described in Table 8 above.
[2] When the microcystin concentration was reported as being less than the reporting limit (1 µg/L), the reported concentration is half the reporting limit (0.5 µg/L).
[3] "RL" means "reporting limit."

Table 10. Summary of TCEQ chlorophyll *a* trend analysis results for the 75 reservoirs for which TCEQ adopted reservoir-specific chlorophyll *a* criteria.

Reservoir Number	Reservoir Name	Segment ID	Chlorophyll *a* Criterion (µg/L)	Using All Chlorophyll *a* Data	Using Only Spectrophotometric Method Chlorophyll *a* Data		Using Only Fluorometric Method Chlorophyll *a* Data	
				Statistically Significant Increasing Trend Identified?	Statistically Significant Increasing Trend Identified?	Trend Still Statistically Significant After Considering Reporting Limit Changes?	Statistically Significant Increasing Trend Identified?	Trend Still Statistically Significant After Considering Reporting Limit Changes?
1	Stillhouse Hollow Lake	1216	5.00	Yes	Yes	No	Yes	No
2	Medina Lake	1904	5.00	No	No[1]		no fluorometric method data	
3	Lake Austin	1403	5.00	No	No		Yes	No
4	Lake Travis	1404	5.00	No	No		No	
5	Lake Georgetown	1249	5.00	Yes	No		Yes	Yes
6	Canyon Lake	1805	5.00	No	No		No	
7	Greenbelt Lake	0223	5.00	No	No		Yes	Yes
8	Lake Cisco	1234	5.00	No	Yes	No	No	
9	Bridgeport Reservoir	0811	5.32	Yes	Yes	Yes	no fluorometric method data	
10	Lake Jacksonville	0614	5.60	No	No		No	
11	Hubbard Creek Reservoir	1233	5.61	Yes	Yes	No	No	
12	O.H. Ivie Reservoir	1433	5.77	No	No		No	
13	Lake Graham	1231	6.07	Yes	No		No	
14	Lake Coleman	1419	6.07	No	No		No	
15	Lake Kickapoo	0213	6.13	No	No		no fluorometric method data	
16	Sam Rayburn Reservoir	0610	6.22	No	No		No	
17	Belton Lake	1220	6.38	Yes	No		No	
18	Oak Creek Reservoir	1426	6.93	Yes	Yes	No	No	
19	Lake Crook	0208	7.38	No	No		no fluorometric method data	
20	Lady Bird Lake (Town Lake)	1429	7.56	Yes	Yes	Yes	Yes	Yes
21	Lake Cherokee	0510	8.25	No	No		no fluorometric method data	
22	Lake Kemp	0217	8.83	No	No		No	
23	Lake Buchanan	1408	9.82	Yes	Yes	Yes	No	

[1] Note that where trends analysis of method-specific data did not show a significant increasing trend, no additional analysis was completed to determine if a trend may be artificial due to reporting limit changes. In such cases, the associated cell within the "Trend Still Statistically Significant After Considering Reporting Limit Changes?" column is filled with gray color.

Reservoir Number	Reservoir Name	Segment ID	Chlorophyll *a* Criterion (µg/L)	Using All Chlorophyll *a* Data	Using Only Spectrophotometric Method Chlorophyll *a* Data		Using Only Fluorometric Method Chlorophyll *a* Data	
				Statistically Significant Increasing Trend Identified?	Statistically Significant Increasing Trend Identified?	Trend Still Statistically Significant After Considering Reporting Limit Changes?	Statistically Significant Increasing Trend Identified?	Trend Still Statistically Significant After Considering Reporting Limit Changes?
24	Lake Lyndon B. Johnson	1406	10.29	Yes	Yes	Yes	No	
25	Marble Falls Lake	1405	10.48	Yes	Yes	Yes	No	
26	Possum Kingdom Lake	1207	10.74	Yes	No		No	
27	Lake Tyler East	0613	10.88	No	No		No	
28	Houston County Lake	0813	11.10	Yes	No		No	
29	Lake Arrowhead	0212	11.21	No	No		No	
30	B. A. Steinhagen Lake	0603	11.67	No	No		no fluorometric method data	
31	Granger Lake	1247	11.72	Yes	No		Yes	Yes
32	Grapevine Lake	0826	11.90	Yes	Yes	Yes	No	
33	Choke Canyon Reservoir	2116	12.05	No	No		no fluorometric method data	
34	Pat Mayse Lake	0209	12.40	No	No		no fluorometric method data	
35	Lake Sweetwater	1237	13.28	No	No		no fluorometric method data	
36	Lake Tyler	0613	13.38	Yes	Yes	No	No	
37	Cox Lake	2454	13.56	No	No		no fluorometric method data	
38	White River Lake	1240	13.85	Yes	Yes	No	No	
39	Aquilla Reservoir	1254	14.10	No	No		No	
40	Twin Buttes Reservoir	1423	14.44	No	No		No	
41	Lake Fork Reservoir	0512	14.50	Yes	Yes	No	no fluorometric method data	
42	Navarro Mills Lake	0817	15.07	No	No		No	
43	Richland-Chambers Reservoir	0836	15.29	Yes	Yes	Yes	no fluorometric method data	
44	Lake Colorado City	1412	15.60	Yes	Yes	Yes	no fluorometric method data	
45	Millers Creek Reservoir	1208	15.65	No	No		no fluorometric method data	
46	Lake Stamford	1235	16.85	No	No		No	
47	Lake Nasworthy	1422	16.91	No	No		No	
48	Lake Corpus Christi	2103	17.17	Yes	Yes	Yes	No	
49	Lake Cypress Springs	0405	17.54	Yes	Yes	No	No	
50	Whitney Lake	1203	18.34	Yes	Yes	Yes	No	
51	Lewisville Lake	0823	18.45	Yes	Yes	Yes	no fluorometric method data	
52	Lake Pat Cleburne	1228	19.04	Yes	Yes	Yes	No	

Reservoir Number	Reservoir Name	Segment ID	Chlorophyll *a* Criterion (µg/L)	Using All Chlorophyll *a* Data	Using Only Spectrophotometric Method Chlorophyll *a* Data		Using Only Fluorometric Method Chlorophyll *a* Data	
				Statistically Significant Increasing Trend Identified?	Statistically Significant Increasing Trend Identified?	Trend Still Statistically Significant After Considering Reporting Limit Changes?	Statistically Significant Increasing Trend Identified?	Trend Still Statistically Significant After Considering Reporting Limit Changes?
53	Lake Limestone	1252	19.26	Yes	No		Yes	Yes
54	Lake Waxahachie	0816	19.77	Yes	Yes	Yes	No	
55	Wright Patman Lake	0302	21.49	No	No		No	
56	Palo Duro Reservoir	0100	21.73	Yes	No		No	
57	Lake Granbury	1205	22.16	Yes	No		No	
58	Bardwell Reservoir	0815	22.84	Yes	Yes	Yes	No	
59	Lake Livingston	0803	22.96	No	No		no fluorometric method data	
60	Waco Lake	1225	23.16	Yes	Yes	Yes	No	
61	Brady Creek Reservoir	1416	24.15	Yes	Yes	Yes	No	
62	Lake Conroe	1012	24.27	No	No		no fluorometric method data	
63	Red Bluff Reservoir	2312	25.14	Yes	No		No	
64	Eagle Mountain Reservoir	0809	25.37	Yes	Yes	Yes	no fluorometric method data	
65	Benbrook Lake	0830	27.15	Yes	Yes	Yes	no fluorometric method data	
66	Lake Palestine	0605	27.34	No	No		No	
67	Proctor Lake	1222	28.15	No	No		No	
68	Cedar Creek Reservoir	0818	30.40	Yes	Yes	Yes	no fluorometric method data	
69	White Rock Lake	0827	33.65	Yes	Yes	Yes	No	
70	Lake Worth	0807	34.18	Yes	Yes	Yes	no fluorometric method data	
71	Lake Tawakoni	0507	37.18	Yes	Yes	Yes	no fluorometric method data	
72	O.C. Fisher Lake	1425	39.13	Yes	Yes	Yes	No	
73	Lake Tanglewood	0229	43.71	Yes	No		Yes	Yes
74	Somerville Lake	1212	53.05	Yes	Yes	Yes	No	
75	Murval Lake	0509	55.80	Yes	Yes	Yes	No	

Table 11. Summary of EPA chlorophyll *a* trend analysis results for the 75 reservoirs for which TCEQ adopted reservoir-specific chlorophyll *a* criteria.

Reservoir Number	Reservoir Name	Segment ID	Chlorophyll *a* Criterion (µg/L)	Slope Magnitude of Trend (µg/L chlorophyll *a*/year)
1	Stillhouse Hollow Lake	1216	5.00	0.005
2	Medina Lake	1904	5.00	0.122
3	Lake Austin	1403	5.00	0.034
4	Lake Travis	1404	5.00	0.011
5	Lake Georgetown	1249	5.00	0.019
6	Canyon Lake	1805	5.00	-0.013
7	Greenbelt Lake	0223	5.00	0.039
8	Lake Cisco	1234	5.00	0.037
9	Bridgeport Reservoir	0811	5.32	0.077
10	Lake Jacksonville	0614	5.60	0.022
11	Hubbard Creek Reservoir	1233	5.61	0.048
12	O.H. Ivie Reservoir	1433	5.77	0.033
13	Lake Graham	1231	6.07	0.099
14	Lake Coleman	1419	6.07	0.065
15	Lake Kickapoo	0213	6.13	0.119
16	Sam Rayburn Reservoir	0610	6.22	0.046
17	Belton Lake	1220	6.38	0.026
18	Oak Creek Reservoir	1426	6.93	0.134
19	Lake Crook	0208	7.38	0.208
20	Lady Bird Lake (Town Lake)	1429	7.56	0.138
21	Lake Cherokee	0510	8.25	0.197
22	Lake Kemp	0217	8.83	0.123
23	Lake Buchanan	1408	9.82	0.151
24	Lake Lyndon B. Johnson	1406	10.29	0.161
25	Marble Falls Lake	1405	10.48	0.133
26	Possum Kingdom Lake	1207	10.74	0.153
27	Lake Tyler East	0613	10.88	0.066
28	Houston County Lake	0813	11.10	0.153
29	Lake Arrowhead	0212	11.21	0.130
30	B. A. Steinhagen Lake	0603	11.67	0.152
31	Granger Lake	1247	11.72	0.189
32	Grapevine Lake	0826	11.90	0.339
33	Choke Canyon Reservoir	2116	12.05	0.181
34	Pat Mayse Lake	0209	12.40	0.206
35	Lake Sweetwater	1237	13.28	0.206
36	Lake Tyler	0613	13.38	0.192
37	Cox Lake	2454	13.56	0.145
38	White River Lake	1240	13.85	0.336
39	Aquilla Reservoir	1254	14.10	0.197
40	Twin Buttes Reservoir	1423	14.44	0.201
41	Lake Fork Reservoir	0512	14.50	0.222
42	Navarro Mills Lake	0817	15.07	0.133
43	Richland-Chambers Reservoir	0836	15.29	0.220
44	Lake Colorado City	1412	15.60	0.616
45	Millers Creek Reservoir	1208	15.65	0.394
46	Lake Stamford	1235	16.85	0.138
47	Lake Nasworthy	1422	16.91	-0.008

Reservoir Number	Reservoir Name	Segment ID	Chlorophyll *a* Criterion (µg/L)	Slope Magnitude of Trend (µg/L chlorophyll *a*/year)
48	Lake Corpus Christi	2103	17.17	0.203
49	Lake Cypress Springs	0405	17.54	0.315
50	Whitney Lake	1203	18.34	0.296
51	Lewisville Lake	0823	18.45	0.355
52	Lake Pat Cleburne	1228	19.04	0.373
53	Lake Limestone	1252	19.26	0.388
54	Lake Waxahachie	0816	19.77	0.301
55	Wright Patman Lake	0302	21.49	0.479
56	Palo Duro Reservoir	0100	21.73	0.421
57	Lake Granbury	1205	22.16	0.439
58	Bardwell Reservoir	0815	22.84	0.268
59	Lake Livingston	0803	22.96	-0.040
60	Waco Lake	1225	23.16	0.400
61	Brady Creek Reservoir	1416	24.15	0.335
62	Lake Conroe	1012	24.27	0.340
63	Red Bluff Reservoir	2312	25.14	0.362
64	Eagle Mountain Reservoir	0809	25.37	0.440
65	Benbrook Lake	0830	27.15	0.351
66	Lake Palestine	0605	27.34	0.498
67	Proctor Lake	1222	28.15	0.405
68	Cedar Creek Reservoir	0818	30.40	0.473
69	White Rock Lake	0827	33.65	0.575
70	Lake Worth	0807	34.18	0.499
71	Lake Tawakoni	0507	37.18	0.619
72	O.C. Fisher Lake	1425	39.13	1.550
73	Lake Tanglewood	0229	43.71	1.256
74	Somerville Lake	1212	53.05	0.699
75	Murval Lake	0509	55.80	0.917

Table 12. Summary of trophic state classification information for 57 of the 75 reservoirs for which TCEQ adopted reservoir-specific chlorophyll *a* criteria.

Reservoir Number	Reservoir Name	Segment ID	Chlorophyll *a* Criterion (µg/L)	2000 Chlorophyll *a* TSI	Change in Chlorophyll *a* TSI	2010 Chlorophyll *a* TSI	2000 Trophic Classification	2010 Trophic Classification
1	Stillhouse Hollow Lake	1216	5.00	32.08	12.12	44.2	Oligotrophic	Mesotrophic
2	Medina Lake	1904	5.00	36.34	7.98	44.32	Mesotrophic	Mesotrophic
3	Lake Austin	1403	5.00	38.36	4.56	42.92	Mesotrophic	Mesotrophic
4	Lake Travis	1404	5.00	38.21	3.07	41.28	Mesotrophic	Mesotrophic
5	Lake Georgetown	1249	5.00	37.06	-2.48	34.58	Mesotrophic	Oligotrophic
6	Canyon Lake	1805	5.00	36.30	11.06	47.36	Mesotrophic	Eutrophic
7	Greenbelt Lake	0223	5.00	36.32	7.98	44.3	Mesotrophic	Mesotrophic
9	Bridgeport Reservoir	0811	5.32	46.61	-4.01	42.6	Eutrophic	Mesotrophic
10	Lake Jacksonville	0614	5.60	36.29	9.23	45.52	Mesotrophic	Eutrophic
11	Hubbard Creek Reservoir	1233	5.61	37.92	9.52	47.44	Mesotrophic	Eutrophic
12	O.H. Ivie Reservoir	1433	5.77	42.53	4.73	47.26	Mesotrophic	Eutrophic
13	Lake Graham	1231	6.07	39.17	8.27	47.44	Mesotrophic	Eutrophic
14	Lake Coleman	1419	6.07	41.07	4.49	45.56	Mesotrophic	Eutrophic
16	Sam Rayburn Reservoir	0610	6.22	35.37	12.69	48.06	Mesotrophic	Eutrophic
17	Belton Lake	1220	6.38	36.12	10.62	46.74	Mesotrophic	Eutrophic
18	Oak Creek Reservoir	1426	6.93	41.51	14.07	55.58	Mesotrophic	Hypereutrophic
20	Lady Bird Lake (Town Lake)	1429	7.56	36.36	13.22	49.58	Mesotrophic	Eutrophic
22	Lake Kemp	0217	8.83	39.02	10.94	49.96	Mesotrophic	Eutrophic
23	Lake Buchanan	1408	9.82	42.57	9.03	51.60	Mesotrophic	Eutrophic
24	Lake Lyndon B. Johnson	1406	10.29	38.81	13.87	52.68	Mesotrophic	Eutrophic
25	Marble Falls Lake	1405	10.48	46.00	5.26	51.26	Eutrophic	Eutrophic
26	Possum Kingdom Lake	1207	10.74	42.19	8.17	50.36	Mesotrophic	Eutrophic
27	Lake Tyler East	0613	10.88	45.05	5.93	50.98	Eutrophic	Eutrophic
28	Houston County Lake	0813	11.10	39.68	13.9	53.58	Mesotrophic	Eutrophic
29	Lake Arrowhead	0212	11.21	43.07	7.99	51.06	Mesotrophic	Eutrophic
30	B. A. Steinhagen Lake	0603	11.67	50.02	0.72	50.74	Eutrophic	Eutrophic
31	Granger Lake	1247	11.72	41.31	7.15	48.46	Mesotrophic	Eutrophic
37	Cox Lake	2454	13.56	47.22	8.02	55.24	Eutrophic	Hypereutrophic
38	White River Lake	1240	13.85	33.74	18.7	52.44	Oligotrophic	Eutrophic
39	Aquilla Reservoir	1254	14.10	41.96	9.68	51.64	Mesotrophic	Eutrophic
40	Twin Buttes Reservoir	1423	14.44	45.60	16.16	61.76	Eutrophic	Hypereutrophic
41	Lake Fork Reservoir	0512	14.50	48.04	7.38	55.42	Eutrophic	Hypereutrophic

Reservoir Number	Reservoir Name	Segment ID	Chlorophyll *a* Criterion (µg/L)	2000 Chlorophyll *a* TSI	Change in Chlorophyll *a* TSI	2010 Chlorophyll *a* TSI	2000 Trophic Classification	2010 Trophic Classification
42	Navarro Mills Lake	0817	15.07	51.05	1.91	52.96	Eutrophic	Eutrophic
43	Richland-Chambers Reservoir	0836	15.29	51.64	-0.38	51.26	Eutrophic	Eutrophic
44	Lake Colorado City	1412	15.60	54.62	11.46	66.08	Eutrophic	Hypereutrophic
46	Lake Stamford	1235	16.85	44.14	11.64	55.78	Mesotrophic	Hypereutrophic
47	Lake Nasworthy	1422	16.91	46.50	8.24	54.74	Eutrophic	Eutrophic
48	Lake Corpus Christi	2103	17.17	49.77	10.97	60.74	Eutrophic	Hypereutrophic
49	Lake Cypress Springs	0405	17.54	48.95	3.87	52.82	Eutrophic	Eutrophic
50	Whitney Lake	1203	18.34	39.96	17.52	57.48	Mesotrophic	Hypereutrophic
54	Lake Waxahachie	0816	19.77	42.24	11.94	54.18	Mesotrophic	Eutrophic
55	Wright Patman Lake	0302	21.49	50.17	-2.79	47.38	Eutrophic	Eutrophic
58	Bardwell Reservoir	0815	22.84	52.30	6.04	58.34	Eutrophic	Hypereutrophic
59	Lake Livingston	0803	22.96	55.95	1.59	57.54	Hypereutrophic	Hypereutrophic
60	Waco Lake	1225	23.16	43.27	10.75	54.02	Mesotrophic	Eutrophic
61	Brady Creek Reservoir	1416	24.15	54.36	4.48	58.84	Eutrophic	Hypereutrophic
62	Lake Conroe	1012	24.27	53.48	5.42	58.9	Eutrophic	Hypereutrophic
63	Red Bluff Reservoir	2312	25.14	50.83	10.75	61.58	Eutrophic	Hypereutrophic
64	Eagle Mountain Reservoir	0809	25.37	53.56	8.4	61.96	Eutrophic	Hypereutrophic
66	Lake Palestine	0605	27.34	51.01	10.45	61.46	Eutrophic	Hypereutrophic
67	Proctor Lake	1222	28.15	52.23	6.45	58.68	Eutrophic	Hypereutrophic
70	Lake Worth	0807	34.18	55.82	-0.04	55.78	Hypereutrophic	Hypereutrophic
71	Lake Tawakoni	0507	37.18	54.25	10.13	64.38	Eutrophic	Hypereutrophic
72	O.C. Fisher Lake	1425	39.13	48.84	15.14	63.98	Eutrophic	Hypereutrophic
73	Lake Tanglewood	0229	43.71	52.88	10.58	63.46	Eutrophic	Hypereutrophic
74	Somerville Lake	1212	53.05	51.37	15.93	67.3	Eutrophic	Hypereutrophic
75	Murval Lake	0509	55.80	64.81	1.55	66.36	Hypereutrophic	Hypereutrophic

Table 13. Percent of individual chlorophyll *a* measurements equal to or greater than 30 µg/L in the underlying chlorophyll *a* dataset available for each of the 75 reservoirs[1] for which TCEQ adopted chlorophyll *a* criteria.

Reservoir Number	Reservoir Name	Segment ID	Chlorophyll *a* Criterion (µg/L)	Percent of Chlorophyll *a* Measurements Within Reservoir-Specific Datasets ≥30 µg/L
1	Stillhouse Hollow Lake	1216	5.00	0
2	Medina Lake	1904	5.00	0
3	Lake Austin	1403	5.00	1
4	Lake Travis	1404	5.00	0
5	Lake Georgetown	1249	5.00	0
6	Canyon Lake	1805	5.00	0
7	Greenbelt Lake	0223	5.00	1
8	Lake Cisco	1234	5.00	0
9	Bridgeport Reservoir	0811	5.32	0
10	Lake Jacksonville	0614	5.60	0
11	Hubbard Creek Reservoir	1233	5.61	0
12	O.H. Ivie Reservoir	1433	5.77	0
13	Lake Graham	1231	6.07	0
14	Lake Coleman	1419	6.07	0
15	Lake Kickapoo	0213	6.13	6
16	Sam Rayburn Reservoir	0610	6.22	1
17	Belton Lake	1220	6.38	0
18	Oak Creek Reservoir	1426	6.93	5
19	Lake Crook	0208	7.38	0
20	Lady Bird Lake (Town Lake)	1429	7.56	1
21	Lake Cherokee	0510	8.25	3
22	Lake Kemp	0217	8.83	0
23	Lake Buchanan	1408	9.82	0
24	Lake Lyndon B. Johnson	1406	10.29	0
25	Marble Falls Lake	1405	10.48	1
26	Possum Kingdom Lake	1207	10.74	3
27	Lake Tyler East	0613	10.88	1
28	Houston County Lake	0813	11.10	1
29	Lake Arrowhead	0212	11.21	0
30	B. A. Steinhagen Lake	0603	11.67	0
31	Granger Lake	1247	11.72	2
32	Grapevine Lake	0826	11.90	0
33	Choke Canyon Reservoir	2116	12.05	0
34	Pat Mayse Lake	0209	12.40	2
35	Lake Sweetwater	1237	13.28	10
36	Lake Tyler	0613	13.38	1
37	Cox Lake	2454	13.56	7
38	White River Lake	1240	13.85	2
39	Aquilla Reservoir	1254	14.10	1
40	Twin Buttes Reservoir	1423	14.44	6
41	Lake Fork Reservoir	0512	14.50	2
42	Navarro Mills Lake	0817	15.07	0
43	Richland-Chambers Reservoir	0836	15.29	1

[1] As provided in supporting documentation that TCEQ provided to EPA on July 7, 2011.

Reservoir Number	Reservoir Name	Segment ID	Chlorophyll *a* Criterion (µg/L)	Percent of Chlorophyll *a* Measurements Within Reservoir-Specific Datasets ≥30 µg/L
44	Lake Colorado City	1412	15.60	4
45	Millers Creek Reservoir	1208	15.65	12
46	Lake Stamford	1235	16.85	1
47	Lake Nasworthy	1422	16.91	2
48	Lake Corpus Christi	2103	17.17	5
49	Lake Cypress Springs	0405	17.54	2
50	Whitney Lake	1203	18.34	5
51	Lewisville Lake	0823	18.45	0
52	Lake Pat Cleburne	1228	19.04	9
53	Lake Limestone	1252	19.26	11
54	Lake Waxahachie	0816	19.77	3
55	Wright Patman Lake	0302	21.49	14
56	Palo Duro Reservoir	0100	21.73	9
57	Lake Granbury	1205	22.16	14
58	Bardwell Reservoir	0815	22.84	4
59	Lake Livingston	0803	22.96	13
60	Waco Lake	1225	23.16	8
61	Brady Creek Reservoir	1416	24.15	9
62	Lake Conroe	1012	24.27	10
63	Red Bluff Reservoir	2312	25.14	11
64	Eagle Mountain Reservoir	0809	25.37	8
65	Benbrook Lake	0830	27.15	18
66	Lake Palestine	0605	27.34	18
67	Proctor Lake	1222	28.15	25
68	Cedar Creek Reservoir	0818	30.40	15
69	White Rock Lake	0827	33.65	32
70	Lake Worth	0807	34.18	14
71	Lake Tawakoni	0507	37.18	19
72	O.C. Fisher Lake	1425	39.13	21
73	Lake Tanglewood	0229	43.71	43
74	Somerville Lake	1212	53.05	39
75	Murval Lake	0509	55.80	39

Table 14. "Snapshot" overview of all the data and information gathered from all of the information sources described in this TSD for all 75 reservoirs, as well as EPA's decisions under CWA §303(c) to approve or disapprove each of the 75 reservoir-specific chlorophyll *a* criteria.

Reservoir Number	Reservoir Name	Segment ID	Chl-a Criterion (µg/L)	Number 303(d) Listings for DO and pH	Number Concerns (Nutrient Enrichment-Related Indicators[1])	Number Concerns (Nutrient[2] Indicators)	TCEQ Identified MCL Exceedances	EPA 2007 NLA Risk (Chl-a)	EPA 2007 NLA Risk (microcystin)	EPA 2007 NLA Risk (cyanobacT)	TCEQ Trend[3]	Was TCEQ's Increasing Trend Statistically Significant?[4]	EPA Trend Analysis - Slope Magnitude of Trend (µg/L Chl-a/year)	Trophic Class - 2000	Trophic Class - 2010	Percent of Chl-a ≥30 µg/L[5]	EPA Action[6]
1	**Stillhouse Hollow Lake**	1216	5.00	0	0	0	N/A[7]	low risk	low risk	low risk	increasing	No	0.005	oligo	meso	0	Approved*
2	**Medina Lake**	1904	5.00	0	0	0	N/A	NS[8]	NS	NS	decreasing	NA[9]	0.122	meso	meso	0	Approved*
3	**Lake Austin**	1403	5.00	1	0	0	N/A	NS	NS	NS	increasing	No	0.034	meso	meso	1	Approved*
4	**Lake Travis**	1404	5.00	0	9, R[10]	0	N/A	NS	NS	NS	increasing	No	0.011	meso	meso	0	Approved*
5	**Lake Georgetown**	1249	5.00	0	0	0	N/A	NS	NS	NS	increasing	Yes	0.019	meso	oligo	0	Approved*
6	**Canyon Lake**	1805	5.00	0	0	4	N/A	NS	NS	NS	decreasing	NA	-0.013	meso	eu	0	Approved*
7	**Greenbelt Lake**	0223	5.00	0	0	0	N/A	NS	NS	NS	increasing	Yes	0.039	meso	meso	1	Approved*
8	**Lake Cisco**	1234	5.00	0	0	0	N/A	low risk	low risk	low risk	increasing	No	0.037	N/A	N/A	0	Approved*
9	**Bridgeport Reservoir**	0811	5.32	0	0	0	N/A	NS	NS	NS	increasing	Yes	0.077	eu	meso	0	Approved*
10	**Lake Jacksonville**	0614	5.60	0	0	0	N/A	low risk	low risk	low risk	increasing	No	0.022	meso	eu	0	Approved
11	**Hubbard Creek Reservoir**	1233	5.61	0	1	0	N/A	NS	NS	NS	increasing	No	0.048	meso	eu	0	Approved*
12	**O.H. Ivie Reservoir**	1433	5.77	0	0	0	N/A	NS	NS	NS	decreasing	NA	0.033	meso	eu	0	Approved*
13	**Lake Graham**	1231	6.07	0	0	0	N/A	NS	NS	NS	increasing	No	0.099	meso	eu	0	Approved*
14	**Lake Coleman**	1419	6.07	0	0	0	N/A	low risk	low risk	low risk	increasing	No	0.065	meso	eu	0	Approved*
15	**Lake Kickapoo**	0213	6.13	0	0	0	N/A	NS	NS	NS	decreasing	NA	0.119	N/A	N/A	6	Approved*
16	**Sam Rayburn Reservoir**	0610	6.22	19, R[11]	0	34, R[12]	N/A	low risk	low risk	moderate risk	increasing	No	0.046	meso	eu	1	Approved
17	**Belton Lake**	1220	6.38	0	2	4	N/A	NS	NS	NS	increasing	No	0.026	meso	eu	0	Approved*
18	**Oak Creek Reservoir**	1426	6.93	0	0	0	N/A	NS	NS	NS	increasing	No	0.134	meso	hyper	5	Approved
19	**Lake Crook**	0208	7.38	0	0	0	N/A	NS	NS	NS	increasing	No	0.208	N/A	N/A	0	Approved*
20	**Lady Bird Lake (Town Lake)**	1429	7.56	0	0	3, R	N/A	NS	NS	NS	increasing	Yes	0.138	meso	eu	1	Approved*
21	**Lake Cherokee**	0510	8.25	0	4, R	2	N/A	NS	NS	NS	increasing	No	0.197	N/A	N/A	3	Approved*
22	**Lake Kemp**	0217	8.83	0	0	0	N/A	low risk	low risk	low risk	increasing	No	0.123	meso	eu	0	Approved*

[1] "Nutrient" means ammonia (NH3-N), nitrate (NO3-N), orthophosphorus (OP), or total phosphorus (TP).
[2] "Nutrient Enrichment-Related Indicator" means DO, pH, chlorophyll *a* (hl-a), harmful algal bloom/golden alga (HAB/GA), or fish kill.
[3] Indicates whether the slope of the chlorophyll *a* trend was increasing or decreasing in TCEQ's trend analysis provided to EPA on October 7, 2011 (based on all chlorophyll *a* data available for each reservoir).
[4] Indicates whether TCEQ's increasing trend (see footnote 3 above) was statistically significant (using a 95% confidence level) after consideration of method or reporting limit changes.
[5] This is the percent of chlorophyll *a* measurements that were ≥30 µg/L in the underlying chlorophyll *a* dataset available for each reservoir (submitted by TCEQ to EPA on July 7, 2011).
[6] As explained in EPA's action letter accompanying this TSD, EPA is approving 31 of the 39 reservoir-specific chlorophyll *a* criteria subject to the outcome of consultation with the U.S. Fish and Wildlife Service under §7(a)(2) of the Endangered Species Act. These 31 criteria are indicated with an asterisk (*) in Table 1 and 14 of this TSD.
[7] "N/A" means "not available."
[8] "NS" means the reservoir was "not sampled" as part of EPA's 2007 National Lakes Assessment Study.
[9] "NA" (without dash) means "not applicable" (because trend was decreasing).
[10] "R" means "Repeating." "Repeating" means either (1) two or more nutrient enrichment-related indicator/assessment unit combinations are repeated in two Integrated Report cycles or (2) at least one nutrient enrichment-related indicator/assessment unit combination is repeated in three Integrated Report cycles.
[11] "R" means "Repeating." "Repeating" means either (1) two or more pH (or DO)/assessment unit combinations are repeated in two Integrated Report cycles or (2) at least pH (or DO)/assessment unit combination is repeated in three Integrated Report cycles.
[12] "R" means "Repeating." "Repeating" means either (1) two or more nutrient/assessment unit combinations are repeated in two Integrated Report cycles or (2) at least one nutrient/assessment unit combination is repeated in three Integrated Report cycles.

Reservoir Number	Reservoir Name	Segment ID	Chl-a Criterion (µg/L)	Number 303(d) Listings for DO and pH	Number Concerns (Nutrient Enrichment-Related Indicators[1])	Number Concerns (Nutrient[2] Indicators)	TCEQ Identified MCL Exceedances	EPA 2007 NLA Risk (Chl-a)	EPA 2007 NLA Risk (microcystin)	EPA 2007 NLA Risk (cyanobacT)	TCEQ Trend[3]	Was TCEQ's Increasing Trend Statistically Significant?[4]	EPA Trend Analysis - Slope Magnitude of Trend (µg/L Chl-a/year)	Trophic Class - 2000	Trophic Class - 2010	Percent of Chl-a ≥30 µg/L[5]	EPA Action[6]
23	**Lake Buchanan**	1408	9.82	0	3, R	0	N/A	NS	NS	NS	increasing	Yes	0.151	meso	eu	0	Approved*
24	**Lake Lyndon B. Johnson**	1406	10.29	0	6, R	0	N/A	NS	NS	NS	increasing	Yes	0.161	meso	eu	0	Approved*
25	**Marble Falls Lake**	1405	10.48	0	0	0	N/A	NS	NS	NS	increasing	Yes	0.133	eu	eu	1	Approved*
26	**Possum Kingdom Lake**	1207	10.74	0	0	0	N/A	NS	NS	NS	increasing	No	0.153	meso	eu	3	Approved*
27	**Lake Tyler East**	0613	10.88	2	0	0	N/A	NS	NS	NS	increasing	No	0.066	eu	eu	1	Approved
28	**Houston County Lake**	0813	11.10	0	0	0	N/A	NS	NS	NS	increasing	No	0.153	meso	eu	1	Approved
29	**Lake Arrowhead**	0212	11.21	0	0	5, R	N/A	NS	NS	NS	increasing	No	0.130	meso	eu	0	Disapproved
30	**B. A. Steinhagen Lake**	0603	11.67	0	0	0	N/A	NS	NS	NS	increasing	No	0.152	eu	eu	0	Approved
31	**Granger Lake**	1247	11.72	0	0	9, R	N/A	NS	NS	NS	increasing	Yes	0.189	meso	eu	2	Disapproved
32	**Grapevine Lake**	0826	11.90	0	0	8, R	N/A	NS	NS	NS	increasing	Yes	0.339	N/A	N/A	0	Disapproved
33	**Choke Canyon Reservoir**	2116	12.05	3, R	5, R	0	N/A	moderate risk	low risk	low risk	decreasing	NA	0.181	N/A	N/A	0	Approved*
34	**Pat Mayse Lake**	0209	12.40	0	1	0	N/A	NS	NS	NS	increasing	No	0.206	N/A	N/A	2	Approved*
35	**Lake Sweetwater**	1237	13.28	0	0	0	N/A	NS	NS	NS	decreasing	NA	0.206	N/A	N/A	10	Disapproved
36	**Lake Tyler**	0613	13.38	0	0	0	N/A	NS	NS	NS	increasing	No	0.192	N/A	N/A	1	Approved
37	**Cox Lake**	2454	13.56	0	2	7, R	N/A	NS	NS	NS	increasing	No	0.145	eu	hyper	7	Disapproved
38	**White River Lake**	1240	13.85	0	0	0	N/A	NS	NS	NS	increasing	No	0.336	oligo	eu	2	Approved*
39	**Aquilla Reservoir**	1254	14.10	7, R	0	9, R	N/A	NS	NS	NS	increasing	No	0.197	meso	eu	1	Disapproved
40	**Twin Buttes Reservoir**	1423	14.44	0	0	7, R	N/A	NS	NS	NS	increasing	No	0.201	eu	hyper	6	Disapproved
41	**Lake Fork Reservoir**	0512	14.50	0	2	2	N/A	NS	NS	NS	increasing	No	0.222	eu	hyper	2	Disapproved
42	**Navarro Mills Lake**	0817	15.07	0	0	3, R	N/A	NS	NS	NS	increasing	No	0.133	eu	eu	0	Approved*
43	**Richland-Chambers Reservoir**	0836	15.29	2	9, R	3, R	N/A	NS	NS	NS	increasing	Yes	0.220	eu	eu	1	Disapproved
44	**Lake Colorado City**	1412	15.60	0	6, R	0	N/A	NS	NS	NS	increasing	Yes	0.616	eu	hyper	4	Disapproved
45	**Millers Creek Reservoir**	1208	15.65	0	3, R	0	N/A	1-moderate risk, 2-low risk	1,2 - low risk	1-low risk, 2-high risk	increasing	No	0.394	N/A	N/A	12	Disapproved
46	**Lake Stamford**	1235	16.85	0	1	0	N/A	NS	NS	NS	increasing	No	0.138	meso	hyper	1	Approved*
47	**Lake Nasworthy**	1422	16.91	0	0	1	N/A	NS	NS	NS	decreasing	NA	-0.008	eu	eu	2	Approved*
48	**Lake Corpus Christi**	2103	17.17	0	5, R	10, R	N/A	NS	NS	NS	increasing	Yes	0.203	eu	hyper	5	Disapproved
49	**Lake Cypress Springs**	0405	17.54	2	5, R	3	N/A	NS	NS	NS	increasing	No	0.315	eu	eu	2	Approved
50	**Whitney Lake**	1203	18.34	0	8, R	2	N/A	N/A	low risk	moderate risk	increasing	Yes	0.296	meso	hyper	5	Disapproved
51	**Lewisville Lake**	0823	18.45	0	0	15, R	N/A	moderate risk	low risk	low risk	increasing	Yes	0.355	N/A	N/A	0	Disapproved
52	**Lake Pat Cleburne**	1228	19.04	0	1	0	N/A	NS	NS	NS	increasing	Yes	0.373	N/A	N/A	9	Approved*

Reservoir Number	Reservoir Name	Segment ID	Chl-a Criterion (µg/L)	Number 303(d) Listings for DO and pH	Number Concerns (Nutrient Enrichment-Related Indicators[1])	Number Concerns (Nutrient[2] Indicators)	TCEQ Identified MCL Exceedances	EPA 2007 NLA Risk (Chl-a)	EPA 2007 NLA Risk (microcystin)	EPA 2007 NLA Risk (cyanobacT)	TCEQ Trend[3]	Was TCEQ's Increasing Trend Statistically Significant?[4]	EPA Trend Analysis - Slope Magnitude of Trend (µg/L Chl-a/year)	Trophic Class - 2000	Trophic Class - 2010	Percent of Chl-a ≥30 µg/L[5]	EPA Action[6]
53	**Lake Limestone**	1252	19.26	0	6, R	1	N/A	NS	NS	NS	increasing	Yes	0.388	N/A	N/A	11	Disapproved
54	**Lake Waxahachie**	0816	19.77	0	0	0	N/A	NS	NS	NS	increasing	Yes	0.301	meso	eu	3	Approved*
55	**Wright Patman Lake**	0302	21.49	51, R	16, R	9, R	none	high risk	low risk	moderate risk	increasing	No	0.479	eu	eu	14	Disapproved
56	**Palo Duro Reservoir**	0100	21.73	5, R	0	5, R	none	NS	NS	NS	increasing	No	0.421	N/A	N/A	9	Disapproved
57	**Lake Granbury**	1205	22.16	0	3	0	none	NS	NS	NS	increasing	No	0.439	N/A	N/A	14	Disapproved
58	**Bardwell Reservoir**	0815	22.84	0	0	3, R	none	NS	NS	NS	increasing	Yes	0.268	eu	hyper	4	Disapproved
59	**Lake Livingston**	0803	22.96	32, R	20, R	58, R	none	moderate risk	low risk	low risk	decreasing	NA	-0.040	hyper	hyper	13	Disapproved
60	**Waco Lake**	1225	23.16	0	4, R	9, R	none	NS	NS	NS	increasing	Yes	0.400	meso	eu	8	Disapproved
61	**Brady Creek Reservoir**	1416	24.15	0	0	0	TTHMs	NS	NS	NS	increasing	Yes	0.335	eu	hyper	9	Disapproved
62	**Lake Conroe**	1012	24.27	0	9, R	0	none	NS	NS	NS	increasing	No	0.340	eu	hyper	10	Disapproved
63	**Red Bluff Reservoir**	2312	25.14	0	11, R	8, R	none	NS	NS	NS	increasing	No	0.362	eu	hyper	11	Disapproved
64	**Eagle Mountain Reservoir**	0809	25.37	0	20, R	4	none	NS	NS	NS	increasing	Yes	0.440	eu	hyper	8	Disapproved
65	**Benbrook Lake**	0830	27.15	0	8, R	3	none	NS	NS	NS	increasing	Yes	0.351	N/A	N/A	18	Disapproved
66	**Lake Palestine**	0605	27.34	7, R	17, R	24, R	none	1,2-moderate risk	1,2 - detected but low risk	1-low risk, 2-moderate risk	increasing	No	0.498	eu	hyper	18	Disapproved
67	**Proctor Lake**	1222	28.15	5, R	8, R	2	none	NS	NS	NS	increasing	No	0.405	eu	hyper	25	Disapproved
68	**Cedar Creek Reservoir**	0818	30.40	52, R	25, R	20, R	HAAs	NS	NS	NS	increasing	Yes	0.473	N/A	N/A	15	Disapproved
69	**White Rock Lake**	0827	33.65	0	0	1	none	moderate risk	detected but low risk	low risk	increasing	Yes	0.575	N/A	N/A	32	Disapproved
70	**Lake Worth**	0807	34.18	0	2	0	none	NS	NS	NS	increasing	Yes	0.499	hyper	hyper	14	Disapproved
71	**Lake Tawakoni**	0507	37.18	7, R	15, R	3	HAAs	NS	NS	NS	increasing	Yes	0.619	eu	hyper	19	Disapproved
72	**O.C. Fisher Lake**	1425	39.13	0	4, R	9, R	none	moderate risk	low risk	moderate risk	increasing	Yes	1.550	eu	hyper	21	Disapproved
73	**Lake Tanglewood**	0229	43.71	0	4, R	10, R	none	NS	NS	NS	increasing	Yes	1.256	eu	hyper	43	Disapproved
74	**Somerville Lake**	1212	53.05	11, R	13, R	0	none	high risk	low risk	moderate risk	increasing	Yes	0.699	eu	hyper	39	Disapproved
75	**Murval Lake**	0509	55.80	0	3, R	1	none	high risk	low risk	high risk	increasing	Yes	0.917	hyper	hyper	39	Disapproved

References

Bigham, D.L., M.V. Hoyer, and D.E. Canfield, Jr. 2009. Survey of toxic algal (microcystin) distribution in Florida lakes. Lake and Reservoir Management 25:264-275.

Carlson, R.E. 1977. A trophic state index for lakes. Limnology and Oceanography 22:361–369.

Chorus, I., I.R. Falconer, H.J. Salas, and J. Bartram. 2000. Health risks caused by freshwater cyanobacteria in recreational waters. Journal of Toxicology and Environmental Health, Part B, 3:323-347.

Dodds, W.K., W.W. Bouska, J.L. Eitzmann, T.J. Pilger, K.L. Pitts, A.J. Riley, J.T. Schloesser, and D.J. Thornbrugh. 2009. Eutrophication of U.S. freshwaters: Analysis of potential economic damages. Environmental Science and Technology 43(1):12–19.

Downing, J.A., S.B. Watson, and E. McCauley. 2001. Predicting cyanobacteria dominance in lakes. Canadian Journal of Fisheries and Aquatic Sciences 58:1905–1908.

Elser, J.J., E.R. Marzolf, and C.R. Goldman. 1990. Phosphorus and nitrogen limitation of phytoplankton growth in the freshwaters of North America: A review and critique of experimental enrichments. Canadian Journal of Fisheries and Aquatic Sciences 47(7):1468–1477.

Graham, J.L., K.A. Loftin, M.T. Meyer, and A.C. Ziegler. 2010. Cyanotoxin mixtures and taste-and-odor compounds in cyanobacterial blooms from the midwestern United States. Environmental Science and Technology 44(19):7361-7368.

Hahn, G.J. and W.Q. Meeker. 1991. Statistical Intervals: A Guide for Practitioners. Wiley Series in Probability and Mathematical Statistics. A Wiley-Interscience Publication. John Wiley & Sons, Inc., New York, NY. pp. 58-73 and 98-99.

Huang, J., N. Graham, M.R. Templeton, Y. Zhang, C. Collins, and M. Nieuwenhuijsen. 2009. A comparison of the role of two blue-green algae in THM and HAA formation. Water Research 43:3009-3018.

Lindon, M. and S. Heiskary. 2009. Blue-green algal toxin (microcystin) levels in Minnesota lakes. Lake and Reservoir Management 25:240-252.

Lopez, C.B., Jewett, E.B., Dortch, Q., Walton, B.T., and Hudnell, K. 2008. Scientific Assessment of Freshwater Harmful Algal Blooms. Interagency Working Group on Harmful Algal Blooms, Hypoxia, and Human Health of the Joint Subcommittee on Ocean Science and Technology. Washington, DC.

NAS. 1969. *Eutrophication: Causes, Consequences, Correctives*. National Academy of Sciences, Washington, DC.

NRC. 2000. Clean Coastal Waters: Understanding and Reducing the Effects of Nutrient Pollution. Report prepared by the Ocean Studies Board and Water Science and Technology Board, Commission on Geosciences, Environment, and Resources, National Research Council. National Academy Press, Washington, DC.

Paerl, H.W. 1988. Nuisance phytoplankton blooms in coastal, estuarine, and inland waters. Limnology and Oceanography 33(4, part 2):823–847.

Smith, V.H. 2003. Eutrophication of freshwater and coastal marine ecosystems. Environmental Science and Pollution Research 10(2):126–139.

Smith, V.H., G.D. Tilman, and J.C. Nekola. 1999. Eutrophication: impacts of excess nutrient inputs on freshwater, marine, and terrestrial ecosystems. Environmental Pollution 100:179-196.

TCEQ. 2010. Guidance for Assessing and Reporting Surface Water Quality in Texas. Texas Commission on Environmental Quality, Austin, Texas.

TCEQ. 2011. Trophic Classification of Texas Reservoirs. Texas Commission on Environmental Quality, Austin, Texas.

TPWD. 2007. Review of the Retrospective Analysis done by the Texas Commission on Environmental Quality for U.S. Environmental Protection Agency Region 6 Regional Technical Advisory Group (RTAG) on January 18, 2006 and a Subsequent Reanalysis Based on Recalculating the Criteria. Texas Parks and Wildlife Department, Austin, Texas.

USEPA. 2000a. Nutrient Criteria Technical Guidance Manual: Rivers and Streams. EPA-822-B-00-002. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.

USEPA. 2000b. Nutrient Criteria Technical Guidance Manual: Lakes and Reservoirs. EPA-822-B-00-001. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USEPA. 2009. National Lakes Assessment: A Collaborative Survey of the Nation's Lakes. EPA 841-R-09-001. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, D.C.

Walker, Jr., W.W. 1985. Statistical bases for mean chlorophyll *a* criteria. *In*: Lake and Reservoir Management: Practical Applications, Proc. 4th Annual Conference, North American Lake Management Society, McAfee, NJ. 390 pp.

Walker, Jr., W.W. and K.E. Havens. 1995. Relating algal bloom frequencies to phosphorus concentrations in Lake Okeechobee. Lake and Reservoir Management 11(1):77-83.

Walmsley, R.D. 1984. A chlorophyll a trophic status classification for South African impoundments. Journal of Environmental Quality 13(1): 97-104.

WHO. 1998. Guidelines for Drinking-Water Quality, 2nd ed. Addendum to Volume 2. Health Criteria and Other Supporting Information. World Health Organization, Geneva, Switzerland.

WHO. 1999. Toxic Cyanobacteria in Water: A guide to their public health consequences, monitoring and management. I. Chorus and J. Bertram (eds.). E &FN Spon. London, England.

WHO. 2003. Guidelines for Safe Recreational Water Environments, Volume 1: Coastal and Fresh Waters, Chapter 8: Algae and Cyanobacteria in Fresh Water. World Health Organization, Geneva, Switzerland.

Technical Support Document
EPA Review of Reservoir-specific Chlorophyll *a* Criteria for 75 Texas Reservoirs

Appendix A – Reservoir Specific Summaries

Table of Contents

1. **Stillhouse Hollow Lake, Segment 1216, Chlorophyll *a* Criterion 5.00 µg/L** 2
2. **Medina Lake, Segment 1904, Chlorophyll *a* Criterion 5.00 µg/L** 5
3. **Lake Austin, Segment 1403, Chlorophyll *a* Criterion 5.00 µg/L** 8
4. **Lake Travis, Segment 1404, Chlorophyll *a* Criterion 5.00 µg/L** 11
5. **Lake Georgetown, Segment 1249, Chlorophyll *a* Criterion 5.00 µg/L** 14
6. **Canyon Lake, Segment 1805, Chlorophyll *a* Criterion 5.00 µg/L** 17
7. **Greenbelt Lake, Segment 0223, Chlorophyll *a* Criterion 5.00 µg/L** 20
8. **Lake Cisco, Segment 1234, Chlorophyll *a* Criterion 5.00 µg/L** 23
9. **Bridgeport Reservoir, Segment 0811, Chlorophyll *a* Criterion 5.32 µg/L** 25
10. **Lake Jacksonville, Segment 0614, Chlorophyll *a* Criterion 5.60 µg/L** 28
11. **Hubbard Creek Reservoir, Segment 1233, Chlorophyll *a* Criterion 5.61 µg/L** 30
12. **O.H. Ivie Reservoir, Segment 1433, Chlorophyll *a* Criterion 5.77 µg/L** 33
13. **Lake Graham, Segment 1231, Chlorophyll *a* Criterion 6.07 µg/L** 36
14. **Lake Coleman, Segment 1419, Chlorophyll *a* Criterion 6.07 µg/L** 38
15. **Lake Kickapoo, Segment 0213, Chlorophyll *a* Criterion 6.13 µg/L** 41
16. **Sam Rayburn Reservoir, Segment 0610, Chlorophyll *a* Criterion 6.22 µg/L** 43
17. **Belton Lake, Segment 1220, Chlorophyll *a* Criterion 6.38 µg/L** 47
18. **Oak Creek Reservoir, Segment 1426, Chlorophyll *a* Criterion 6.93 µg/L** 50
19. **Lake Crook, Segment 0208, Chlorophyll *a* Criterion 7.38 µg/L** 52
20. **Lady Bird Lake (Town Lake), Segment 1429, Chlorophyll *a* Criterion 7.56 µg/L** 54
21. **Lake Cherokee, Segment 0510, Chlorophyll *a* Criterion 8.25 µg/L** 57
22. **Lake Kemp, Segment 0217, Chlorophyll *a* Criterion 8.83 µg/L** 59
23. **Lake Buchanan, Segment 1408, Chlorophyll *a* Criterion 9.82 µg/L** 62
24. **Lake Lyndon B. Johnson, Segment 1406, Chlorophyll *a* Criterion 10.29 µg/L** 65
25. **Marble Falls Lake, Segment 1405, Chlorophyll *a* Criterion 10.48 µg/L** 68
26. **Possum Kingdom Lake, Segment 1207, Chlorophyll *a* Criterion 10.74 µg/L** 70
27. **Lake Tyler East, Segment 0613, Chlorophyll *a* Criterion 10.88 µg/L** 73
28. **Houston County Lake, Segment 0813, Chlorophyll *a* Criterion 11.10 µg/L** 75
29. **Lake Arrowhead, Segment 0212, Chlorophyll *a* Criterion 11.21 µg/L** 78

30. B.A. Steinhagen Lake, Segment 0603, Chlorophyll *a* Criterion 11.67 µg/L 80
31. Granger Lake, Segment 1247, Chlorophyll *a* Criterion 11.72 µg/L 83
32. Grapevine Lake, Segment 0826, Chlorophyll *a* Criterion 11.90 µg/L 85
33. Choke Canyon Reservoir, Segment 2116, Chlorophyll *a* Criterion 12.05 µg/L 88
34. Pat Mayse Lake, Segment 0209, Chlorophyll *a* Criterion 12.40 µg/L 90
35. Lake Sweetwater, Segment 1237, Chlorophyll *a* Criterion 13.28 µg/L 92
36. Lake Tyler, Segment 0613, Chlorophyll *a* Criterion 13.38 µg/L 94
37. Cox Lake, Segment 2454, Chlorophyll *a* Criterion 13.56 µg/L 97
38. White River Lake, Segment 1240, Chlorophyll *a* Criterion 13.85 µg/L 100
39. Aquilla Reservoir, Segment 1254, Chlorophyll *a* Criterion 14.10 µg/L 102
40. Twin Buttes Reservoir, Segment 1423, Chlorophyll *a* Criterion 14.44 µg/L 105
41. Lake Fork Reservoir, Segment 0512, Chlorophyll *a* Criterion 14.50 µg/L 108
42. Navarro Mills Lake, Segment 0817, Chlorophyll *a* Criterion 15.07 µg/L 111
43. Richland Chambers Reservoir, Segment 0836, Chlorophyll *a* Criterion 15.29 µg/L 113
44. Lake Colorado City, Segment 1412, Chlorophyll *a* Criterion 15.60 µg/L 116
45. Millers Creek Reservoir, Segment 1208, Chlorophyll *a* Criterion 15.65 µg/L 119
46. Lake Stamford, Segment 1235, Chlorophyll *a* Criterion 16.85 µg/L 122
47. Lake Nasworthy, Segment 1422, Chlorophyll *a* Criterion 16.91 µg/L 125
48. Lake Corpus Christi, Segment 2103, Chlorophyll *a* Criterion 17.17 µg/L 127
49. Lake Cypress Springs, Segment 0405, Chlorophyll *a* Criterion 17.54 µg/L 130
50. Whitney Lake, Segment 1203, Chlorophyll *a* Criterion 18.34 µg/L 133
51. Lewisville Lake, Segment 0823, Chlorophyll *a* Criterion 18.45 µg/L 136
52. Lake Pat Cleburne, Segment 1228, Chlorophyll *a* Criterion 19.04 µg/L 139
53. Lake Limestone, Segment 1252, Chlorophyll *a* Criterion 19.26 µg/L 141
54. Lake Waxahachie, Segment 0816, Chlorophyll *a* Criterion 19.77 µg/L 144
55. Wright Patman Lake, Segment 0302, Chlorophyll *a* Criterion 21.49 µg/L 147
56. Palo Duro Reservoir, Segment 0100, Chlorophyll *a* Criterion 21.73 µg/L 151
57. Lake Granbury, Segment 1205, Chlorophyll *a* Criterion 22.16 µg/L 153
58. Bardwell Reservoir, Segment 0815, Chlorophyll *a* Criterion 22.84 µg/L 156
59. Lake Livingston, Segment 0803, Chlorophyll *a* Criterion 22.96 µg/L 159
60. Waco Lake, Segment 1225, Chlorophyll *a* Criterion 23.16 µg/L 164
61. Brady Creek Reservoir, Segment 1416, Chlorophyll *a* Criterion 24.15 µg/L 167
62. Lake Conroe, Segment 1012, Chlorophyll *a* Criterion 24.27 µg/L 169
63. Red Bluff Reservoir, Segment 2312, Chlorophyll *a* Criterion 25.14 µg/L 172
64. Eagle Mountain Reservoir, Segment 0809, Chlorophyll *a* Criterion 25.37 µg/L 175

65. Benbrook Lake, Segment 0830, Chlorophyll *a* Criterion 27.15 µg/L 179
66. Lake Palestine, Segment 0605, Chlorophyll *a* Criterion 27.34 µg/L 182
67. Proctor Lake, Segment 1222, Chlorophyll *a* Criterion 28.15 µg/L 186
68. Cedar Creek Reservoir, Segment 0818, Chlorophyll *a* Criterion 30.40 µg/L 188
69. White Rock Lake, Segment 0827, Chlorophyll *a* Criterion 33.65 µg/L 193
70. Lake Worth, Segment 0807, Chlorophyll *a* Criterion 34.18 µg/L 196
71. Lake Tawakoni, Segment 0507, Chlorophyll *a* Criterion 37.18 µg/L 198
72. O.C. Fisher Lake, Segment 1425, Chlorophyll *a* Criterion 39.13 µg/L 201
73. Lake Tanglewood, Segment 0229, Chlorophyll *a* Criterion 43.71 µg/L 205
74. Somerville Lake, Segment 1212, Chlorophyll *a* Criterion 53.05 µg/L 208
75. Murval Lake, Segment 0509, Chlorophyll *a* Criterion 55.80 µg/L 211

Technical Support Document
EPA Review of Reservoir-specific Chlorophyll *a* Criteria for 75 Texas Reservoirs

Appendix A – Reservoir Specific Summaries

As described more fully in the accompanying Technical Support Document (TSD) titled "EPA Review of Chlorophyll *a* Criteria for 75 Texas Reservoirs," the critical assumption underlying TCEQ's historical ambient period approach to chlorophyll *a* criteria derivation is that the existing, long-term average condition in these reservoirs is sufficient to protect the applicable recreation, aquatic life, and domestic water supply uses in these reservoirs. EPA considers this assumption to be a critical underlying assumption that must be satisfied in order to conclude that a given reservoir-specific chlorophyll *a* criterion is protective of the reservoir's designated uses as required by 40 CFR §131.11(a)(1). Where available reservoir-specific data and information demonstrate that this critical underlying assumption is not satisfied, EPA can conclude that the chlorophyll *a* criterion is not protective of the reservoir's uses as required by 40 CFR §131.11(a)(1).

EPA relied on several sources of publicly available information to independently test TCEQ's critical underlying assumption by evaluating whether each reservoir's uses were sufficiently protected with respect to nutrient impacts during the period of time over which chlorophyll *a* data used in the criteria derivation were collected. In summary, where available reservoir-specific data and information show one of the following scenarios for a given reservoir, EPA concludes that TCEQ's critical underlying assumption is not satisfied:[1]

1. Reservoirs where TCEQ's 2010 trophic classification report indicates a hypereutrophic classification in both the 2000 and 2010 Integrated Report cycles.
2. Reservoirs where TCEQ's 2010 trophic classification report indicates a mesotrophic or eutrophic classification in the 2000 Integrated Report cycle with a shift to a hypereutrophic classification in the 2010 Integrated Report cycle.
3. Reservoirs where 10% or more of the individual chlorophyll *a* measurements included in the underlying chlorophyll *a* dataset available for each reservoir are equal to or greater than 30 µg/L.
4. Reservoirs where the magnitude of the slope of the trend determined from EPA's trend analysis using TCEQ's chlorophyll *a* data was equal to or greater than 0.1 µg/L but less than 0.2 µg/L chlorophyll *a*/ year (i.e., relatively moderate accumulation rate), and TCEQ identified five or more nutrient concerns in the 2006 through 2010 Integrated Report cycles that are repeating.[2]
5. Reservoirs where the magnitude of the slope of the trend determined from EPA's trend analysis using TCEQ's chlorophyll *a* data was equal to or greater than 0.2 µg/L chlorophyll *a*/ year (i.e., relatively high or very high accumulation rate), and TCEQ identified three or more nutrient concerns in the 2006 through 2010 Integrated Report cycles that are repeating.

Where reservoir-specific data and information show one of the five scenarios described above, reservoir-specific information available from the other information sources examined generally corroborates that TCEQ's critical underlying assumption is not satisfied.

[1] Note that there are two reservoirs (Oak Creek Reservoir and Lake Stamford) which showed Scenario 2, but which, for reasons described in Appendix A, EPA is not disapproving the reservoir-specific chlorophyll *a* criteria.
[2] "Repeating" means either (1) two or more nutrient/assessment unit combinations are repeated in two Integrated Report cycles or (2) at least one nutrient/assessment unit combination is repeated in three Integrated Report cycles.

Each reservoir-specific summary below presents all of the data and information that EPA gathered for a given reservoir from each information source described in the accompanying TSD. Each reservoir-specific summary also describes the overall conclusion that EPA reached for each reservoir regarding the protectiveness of the chlorophyll *a* criterion in light of all of the data and information available for that reservoir, and the resulting EPA action based on the overall conclusion.

1. Stillhouse Hollow Lake, Segment 1216, Chlorophyll *a* Criterion 5.00 µg/L (Approved*[3])

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 79 measurements collected between July 9, 1990, and September 9, 2008. Of these 79 measurements, 14 were considered to be outliers because they had values greater than 3.775 µg/L. So, the calculated criterion of 2.07 µg/L for Stillhouse Hollow Lake was derived using a final dataset consisting of 65 chlorophyll *a* measurements collected between July 9, 1990, and July 29, 2008, all of which were equal to or below 3.6 µg/L. Rather than adopt the calculated criterion of 2.07 µg/L, TCEQ set the chlorophyll *a* criterion for Stillhouse Hollow Lake at a minimum default criterion of 5.00 µg/L, a level that TCEQ explains could generally be historically quantified by laboratory chemical analyses. EPA's review of TCEQ's use of the minimum default criterion for Stillhouse Hollow Lake is described below.

Review of Use of Minimum Default Criterion: TCEQ provided additional information on the adoption of a chlorophyll *a* criterion of 5.0 µg/L in the eight reservoirs where the calculated criterion was less than 5.0 µg/L. In 2000, TCEQ established requirements for ambient water reporting limits (AWRLs) and limits of quantitation (LOQ), in the surface water monitoring program. The LOQ is the minimum level, concentration, or quantity of a target variable (e.g., target analyte) that can be reported with a specified degree of confidence. The use of LOQs replaces the use of method detection limit (MDL) or minimum analytical limit (MAL). The AWRL establishes the allowable upper limit for a particular parameter that must be achieved by the LOQ in order for data to be incorporated into the TCEQ SWQMIS database.

Prior to 2000, the MDL or MAL based on use of the spectrophotometric method was often reported as 1 µg/L, but depended on instrument capabilities at individual laboratories. From 2000 to 2005, a LOQ of 10 µg/L was reported for samples analyzed by the spectrophotmetric method, which has been since reduced to 5 µg/L and then 3 µg/L. The fluorometric method has also been used for chlorophyll *a* analyses since 2001. The LOQs for the fluorometric method have been 5 µg/L, 3.3 µg/L and most recently 3 µg/L. Because the dataset for each reservoir may contain measurements based on both the spectrophotometrical method and the fluorometric method, along with a range of values for the LOQ/MDL/MAL (referred to throughout the remainder of Appendix A more generally as "minimum reporting limits"), EPA reviewed TCEQ's justification for the use of the default criterion, along with the other sources of information.

As noted above, the calculated chlorophyll *a* criterion for Stillhouse Hollow Lake is 2.07 µg/L. Of the 65 measurements used in the derivation of this criterion, 55 measurements (85%) were reported as less than the minimum reporting limits. The analytical method for 45 of these measurements used a LOQ of 3.3 µg/L and the remaining ten samples were analyzed with either a LOQ of 5 µg/L or a MDL of 1 µg/L (data collected before 2000). Where a MDL of 1 µg/L was reported, TCEQ retained that measurement value in the criterion derivation, rather than substituting a value of half the MDL.

[3] As explained in EPA's action letter accompanying this TSD, EPA is approving 31 of the 39 reservoir-specific chlorophyll *a* criteria subject to the outcome of consultation with the U.S. Fish and Wildlife Service under §7(a)(2) of the Endangered Species Act (ESA). Approvals subject to the outcome of ESA consultation are indicated with an asterisk (*) following the word "Approved" in the reservoir-specific summary headings found throughout Appendix A.

Clean Water Act (CWA) Section (§) 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for dissolved oxygen (DO) or pH were identified for Stillhouse Hollow Lake.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, no water quality concerns[4] for any nutrient[5] or nutrient enrichment-related indicators[6] were identified for Stillhouse Hollow Lake.

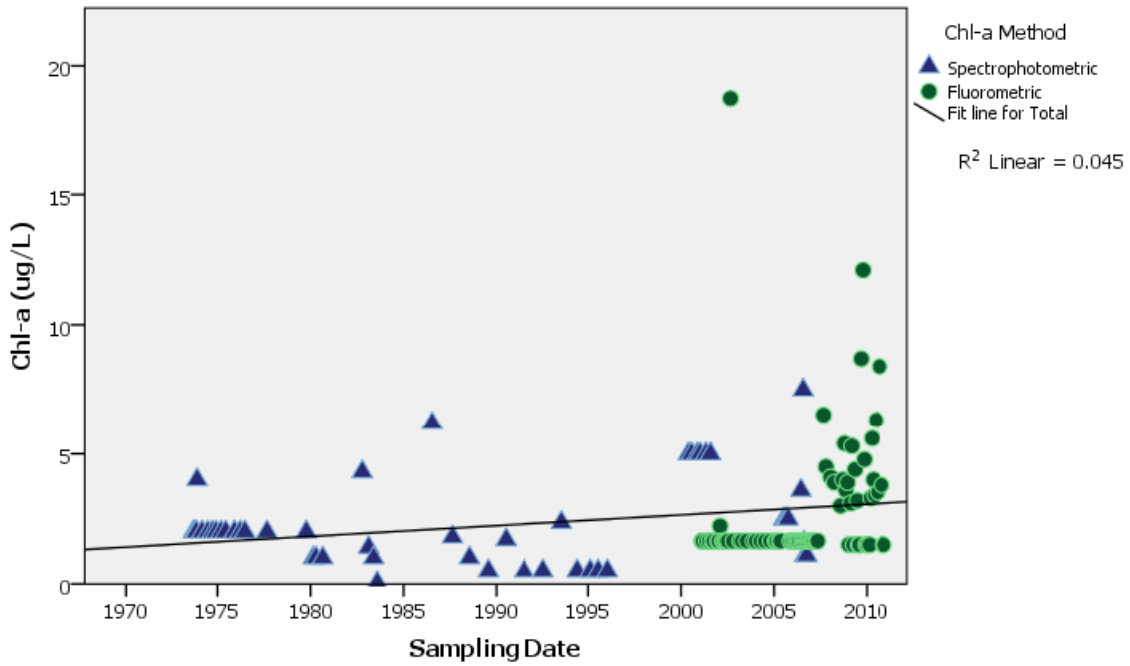
Treated Drinking Water Chemical Data: No information regarding occurrences of Safe Drinking Water Act (SDWA) maximum contaminant level (MCL) exceedances was available for Stillhouse Hollow Lake in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Stillhouse Hollow Lake was sampled one time as part of the 2007 National Lakes Assessment (NLA). The chlorophyll *a* concentration measured during sampling was 3.89 µg/L, indicating a low risk of exposure based on the chlorophyll *a* thresholds used in the NLA study. The microcystin concentration during sampling was below the reporting limit of 0.1 µg/L, indicating a low risk of exposure based on the microcystin thresholds used in the NLA study. The cyanobacteria cell count during sampling was less than 20,000 cells per milliliter, indicating a low risk of exposure based on the cyanobacteria thresholds used in the NLA study.

TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 131 chlorophyll *a* measurements collected from Stillhouse Hollow Lake between 1973 and 2010 (see Figure 1). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Stillhouse Hollow Lake. Based upon the supporting information provided by TCEQ, a shift in methodology does appear to have occurred for this dataset in 2001 (most data after 2001 was collected using the fluorometric method rather than the spectrophotometric method). Fifty-one chlorophyll *a* measurements were made using the spectrophotometric method, with 38 of these measurements (~75%) being reported as less than the minimum reporting limits. Eighty measurements were made using the fluorometric method, with 54 of these measurements (~68%) being reported as less than the minimum reporting limits. When TCEQ analyzed trends for each of these datasets separately, the chlorophyll *a* data collected using the spectrophotometric method did show a statistically significant increasing trend, as did chlorophyll *a* data collected using the fluorometric method. However, for each of these datasets, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) affected the statistical significance of these chlorophyll *a* trends to such a degree that the increasing trends for Stillhouse Hollow Lake were no longer considered statistically significant.

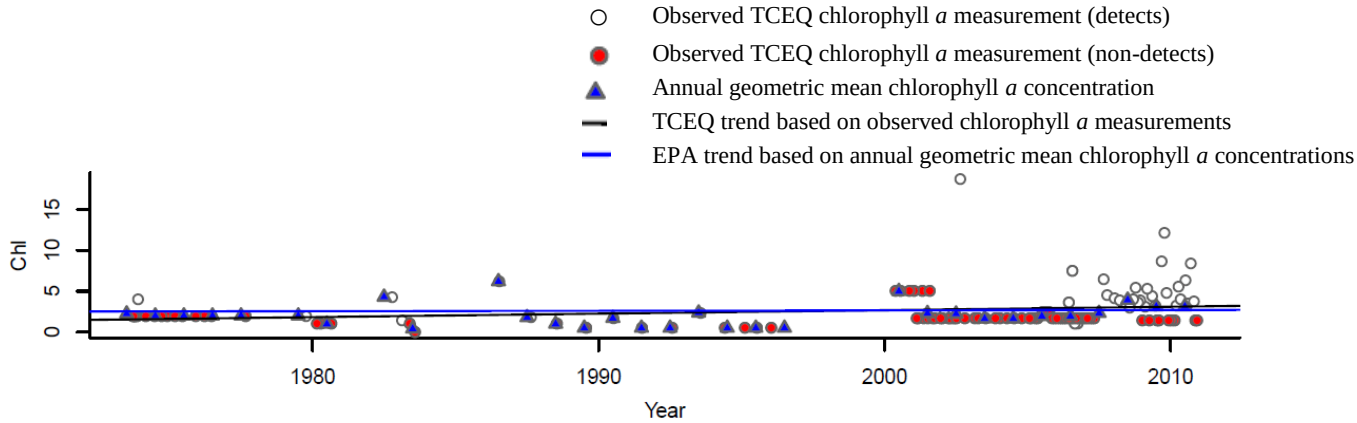
[4] One concern is any nutrient (or nutrient enrichment-related indicator)/assessment unit/Integrated Report year combination.
[5] In this TSD, "nutrient" means ammonia (NH3-N), nitrate (NO3-N), orthophosphorus (OP), or total phosphorus (TP).
[6] In this TSD, "nutrient enrichment-related indicator" means DO, pH, chlorophyll *a* (chl-a), harmful algal bloom/golden alga (HAB/GA), or fish kill

Figure 1. Chlorophyll *a* Trend for Stillhouse Hollow Lake Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Stillhouse Hollow Lake based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 2). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Stillhouse Hollow Lake, the magnitude of the slope of this increasing trend was relatively small at 0.005 µg/L chlorophyll *a*/year.

Figure 2. Chlorophyll *a* Trends for Stillhouse Hollow Lake Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Stillhouse Hollow Lake was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Stillhouse Hollow Lake between the 2000 and 2010 reporting cycles.

According to the report, a Carlson's trophic state index (TSI) value of 44.2 was determined for the 2010 reporting cycle for Stillhouse Hollow Lake. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 12.12 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Stillhouse Hollow Lake shifted from an oligotrophic classification for the 2000 reporting cycle to a mesotrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for Stillhouse Hollow Lake against chlorophyll *a* concentrations published in the scientific literature that reflect elevated risks to aquatic life and human health. While there are no universally accepted or widely applied chlorophyll *a* thresholds that indicate or predict adverse effects to aquatic life and/or human health in reservoirs, there is a large body of scientific evidence that points to chlorophyll *a* concentrations greater than 30 µg/L as a level of phytoplankton biomass associated with nuisance algal blooms (Walmsley 1984, Walker 1985, Walker and Havens 1995), toxic cyanobacteria and toxin production (Chorus et al. 2000, Bigham et al. 2009, Lindon and Heiskary 2009), taste and odor compound production (Graham et al., 2010), and generation of disinfection byproducts in finished drinking water (Huang et al. 2009). In addition to comparing the chlorophyll *a* criterion for Stillhouse Hollow Lake to this 30 µg/L threshold, EPA also independently evaluated TCEQ's underlying chlorophyll *a* dataset for Stillhouse Hollow Lake to explore the frequency and intensity of algal blooms. EPA quantified the number of individual chlorophyll *a* measurements with concentrations greater than 30 µg/L and expressed this as a fraction of the total number of chlorophyll *a* samples in the dataset (i.e., frequency of occurrence). For Stillhouse Hollow Lake, the chlorophyll *a* criterion is below 30 µg/L and 0% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Stillhouse Hollow Lake, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of Stillhouse Hollow Lake. Reservoir-specific data and information described above indicates a worst-case mesotrophic classification for this reservoir, with a relatively small rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.005 µg/L chlorophyll *a*/year) and an increasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. EPA strongly considered the relatively small rate of increasing chlorophyll *a*, the lack of a statistically significant increasing trend, and the relatively large portion of the dataset measured below minimum reporting limits, when evaluating the adoption of the default criterion for Stillhouse Hollow Lake. Additionally, TCEQ did not identify any CWA §303(d) listings for pH or DO for Stillhouse Hollow Lake, nor did it identify any concerns for nutrient or nutrient-enrichment related indicators. Further, 2007 NLA data indicated a low risk of exposure based on chlorophyll *a*, microcystin, and cyanobacteria thresholds, and none of the measurements in the underlying chlorophyll *a* dataset available for Stillhouse Hollow Lake were greater than 30 µg/L. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 5.00 µg/L applicable to Stillhouse Hollow Lake is protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

2. <u>Medina Lake, Segment 1904, Chlorophyll *a* Criterion 5.00 µg/L (Approved*)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 72 measurements collected between September 21, 1973, and August 31,

1994. Of these 72 measurements, 14 were considered to be outliers because they had values greater than 2 µg/L. So, the calculated criterion of 2.15 µg/L for Medina Lake was derived using a final dataset consisting of 58 chlorophyll *a* measurements collected between September 21, 1973, and August 31, 1994, all of which were equal to or below 2 µg/L. Rather than adopt the calculated criterion of 2.15 µg/L, TCEQ set the chlorophyll *a* criterion for Medina Lake at a minimum default criterion of 5.00 µg/L, a level that TCEQ explains could generally be historically quantified by laboratory chemical analyses. EPA's review of TCEQ's use of the minimum default criterion for Medina Lake is described further below.

Review of Use of Minimum Default Criterion: As noted above, the calculated criterion for Medina Lake is 2.15 µg/L. Of the 58 measurements used in the derivation of the chlorophyll *a* criterion for Medina Lake, 54 measurements (93%) were reported as less than the minimum reporting limits. The analytical method for 46 of these measurements used a MDL of 4 µg/l and the other eight samples were analyzed with a MDL of 1 µg/L. EPA also considered TCEQ's concern regarding the age of certain data sets. Where a MDL of 1 µg/L was reported, TCEQ retained that measurement value in the criterion derivation, rather than substituting a value of half the MDL.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Medina Lake.

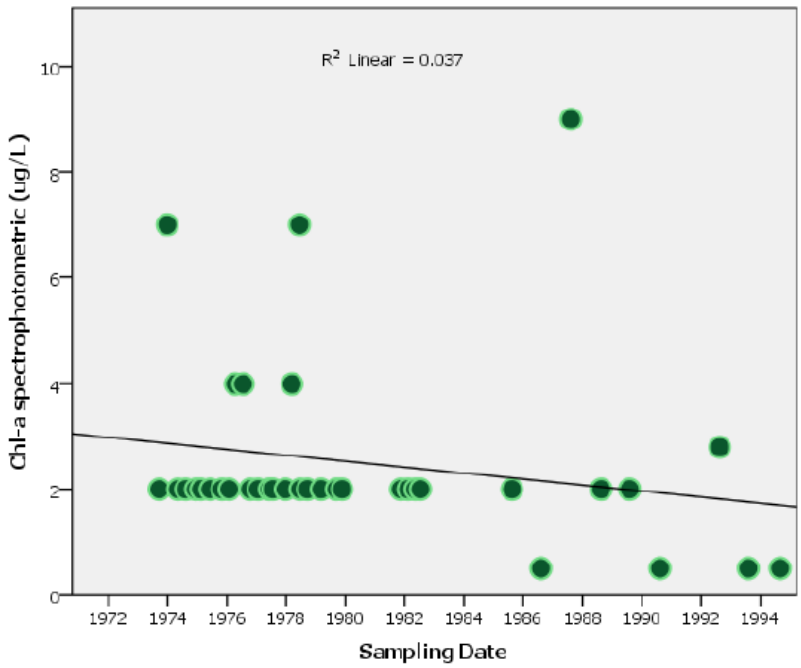
Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, no water quality concerns for any nutrient or nutrient enrichment-related indicators were identified for Medina Lake.

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Medina Lake in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Medina Lake was not sampled as part of the 2007 NLA.

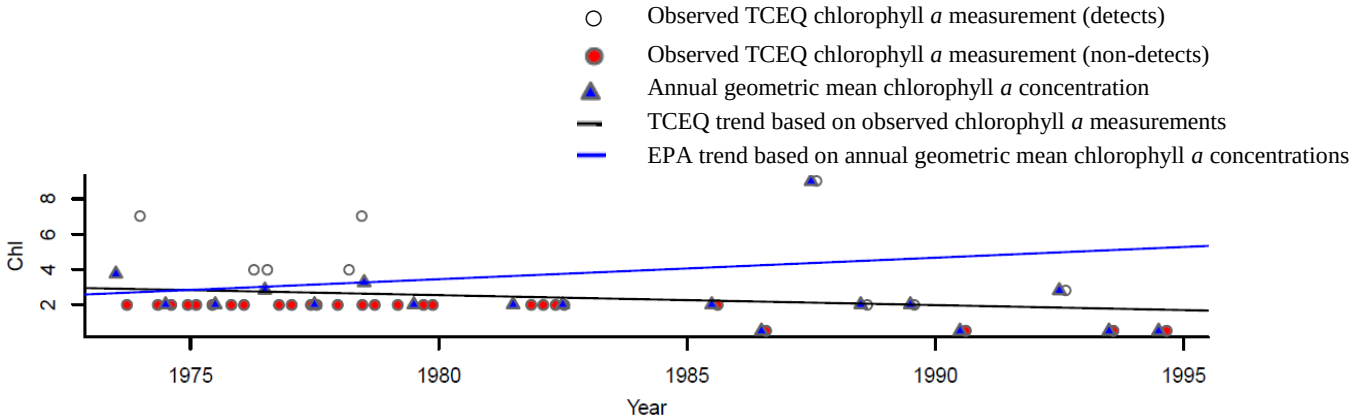
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ did not identify any statistically significant increasing trends in chlorophyll *a* concentrations for Medina Lake (see Figure 3).

Figure 3. Chlorophyll *a* Trend for Medina Lake Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Medina Lake based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 4). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Medina Lake, the magnitude of the slope of this increasing trend was relatively moderate at 0.122 µg/L chlorophyll *a*/year.

Figure 4. Chlorophyll *a* Trends for Medina Lake Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Medina Lake was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Medina Lake between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 44.32 was determined for the 2010 reporting cycle for Medina Lake. This value

was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 7.98 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Medina Lake was mesotrophic for both the 2000 and 2010 reporting cycles.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Medina Lake, the chlorophyll *a* criterion is below 30 µg/L and 0% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Medina Lake, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of Medina Lake. Reservoir-specific data and information described above indicates a mesotrophic classification for this reservoir, with a relatively moderate rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.122 µg/L chlorophyll *a*/year) and a decreasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. EPA strongly considered the lack of a statistically significant increasing trend, along with the large portion of the dataset measured below minimum reporting limits, and the trophic classification of mesotrophic in both 2000 and 2010 when evaluating the adoption of the default criterion for Medina Lake. Additionally, TCEQ did not identify any CWA §303(d) listings for pH or DO for Medlina Lake, nor did it identify any concerns for nutrient or nutrient-enrichment related indicators. Further, none of the measurements in the underlying chlorophyll *a* dataset available for Medina Lake were greater than 30 µg/L. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 5.00 µg/L applicable to Medina Lake is protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

3. <u>Lake Austin, Segment 1403, Chlorophyll *a* Criterion 5.00 µg/L (Approved*)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 156 measurements collected between January 30, 1990, and December 17, 2008. Of these 156 measurements, 11 were considered to be outliers because they had values greater than 6.9325 µg/L. So, the calculated criterion of 3.58 µg/L for Lake Austin was derived using a final dataset consisting of 145 chlorophyll *a* measurements collected between January 30, 1990, and December 17, 2008, all of which were equal to or below 6.91 µg/L. Rather than adopt the calculated criterion of 3.58 µg/L, TCEQ set the chlorophyll *a* criterion for Lake Austin at a minimum default criterion of 5.00 µg/L, a level that TCEQ explains could generally be historically quantified by laboratory chemical analyses. EPA's review of TCEQ's use of the minimum default criterion for Lake Austin is described further below.

Review of Use of Minimum Default Criterion: As noted above, the calculated chlorophyll *a* criterion for Lake Austin is is 3.58 µg/L. Of the 145 measurements used in the derivation of this criterion, 49 measurements (34%) were reported as less than the minimum reporting limits. The analytical method for 16 of these measurements used a LOQ of 5 µg/L and seven other measurements used a MDL/MAL of 10 µg/L or an LOQ of 2 µg/L. Where an MDL of 1 µg/L was reported, TCEQ retained that measurement value in the criterion derivation, rather than substituting a value of half the MDL. The dataset for Lake

Austin also included 18 samples reported at less than a MDL/MAL of 0.5 µg/L. In this case, a value of 1 µg/L was used for derivation of the criterion.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for pH and DO listings in the 2000 through 2010 reporting cycles, the following 303(d) listings were identified for Lake Austin:

Year	Parameter	Assessment Unit	Assessment Unit Description
2000	DO	n/a	Upper 3 miles of the segment

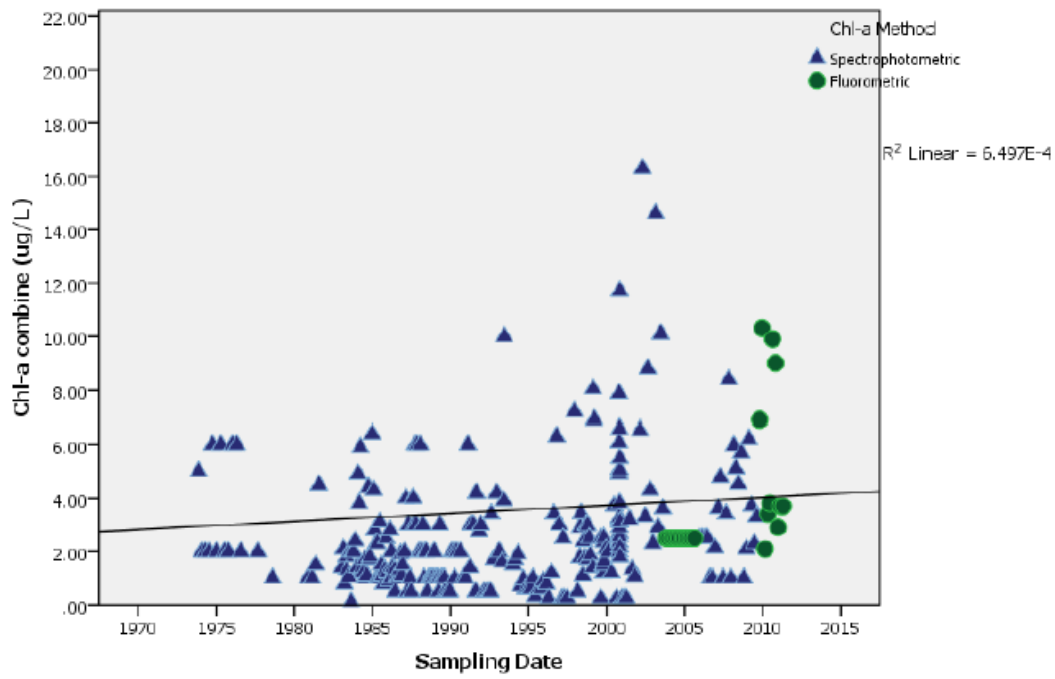
Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, no water quality concerns for any nutrient or nutrient enrichment-related indicators were identified for Lake Austin.

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Lake Austin in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Lake Austin was not sampled as part of the 2007 NLA.

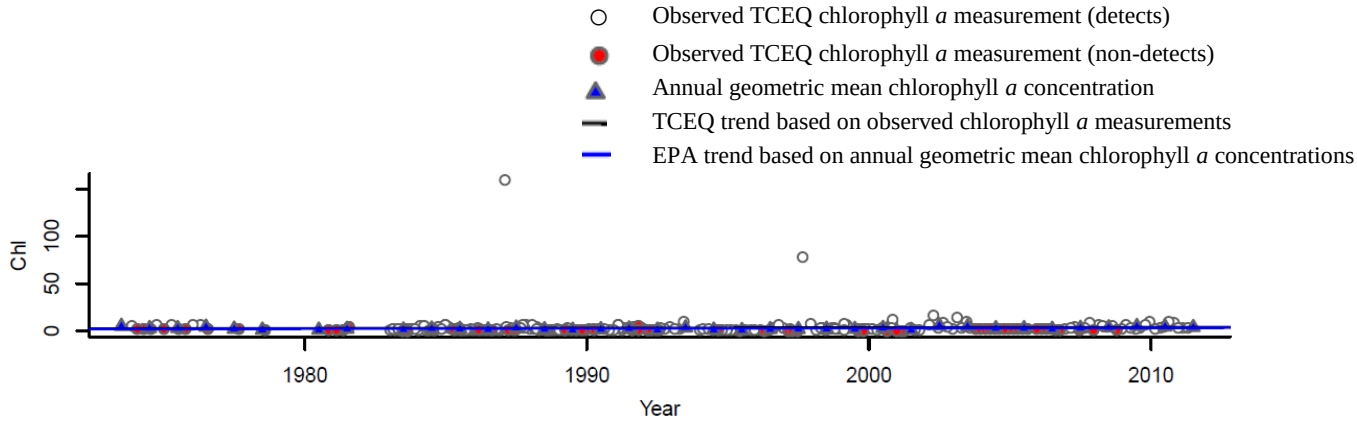
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ did not identify a statistically significant increasing trend using 270 chlorophyll *a* measurements collected from Lake Austin between 1973 and 2011 (see Figure 5). However, when TCEQ analyzed trends separately for chlorophyll *a* data collected using the spectrophotometric method and chlorophyll *a* data collected using the fluorometric data, the chlorophyll *a* data collected using the fluorometric method did show a statistically significant increasing trend. Because TCEQ noted that changes in reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the fluorometric method dataset for Lake Austin. Twenty-two chlorophyll *a* measurements were made using the fluorometric method, with 12 of these measurements (~55%) reported as being less than the reporting limits. In further analyzing the fluorometric method dataset, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) affected the statistical significance of this chlorophyll *a* trend to such a degree that the increasing trend for Lake Austin was no longer considered statistically significant.

Figure 5. Chlorophyll *a* Trend for Lake Austin Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Lake Austin based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 6). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Lake Austin, the magnitude of the slope of this increasing trend was relatively small at 0.034 µg/L chlorophyll *a*/year.

Figure 6. Chlorophyll *a* Trends for Lake Austin Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Lake Austin was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Lake Austin between the 2000 and 2010 reporting cycles. According to the report, a

Carlson's TSI value of 42.92 was determined for the 2010 reporting cycle for Lake Austin. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 4.56 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Lake Austin was mesotrophic for both the 2000 and 2010 reporting cycles.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Lake Austin, the chlorophyll *a* criterion is below 30 µg/L but 1% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Lake Austin, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of Lake Austin. Reservoir-specific data and information described above indicates a mesotrophic classification for this reservoir, with a relatively small rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.034 µg/L chlorophyll *a*/year) and an increasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. EPA strongly considered the relatively small rate of increasing chlorophyll *a*, the lack of a statistically significant increasing trend, and the trophic classification of mesotrophic in both 2000 and 2010, when evaluating the adoption of the default criterion for Lake Austin. Additionally, TCEQ only identified one CWA §303(d) listing for DO for the upper segment of the lake in 2000, and did not identify any concerns for nutrient or nutrient-enrichment related indicators. Further, only 1% of the measurements in the underlying chlorophyll *a* dataset available for Lake Austin were greater 30 µg/L. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 5.00 µg/L applicable to Lake Austin is protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

4. <u>Lake Travis, Segment 1404, Chlorophyll *a* Criterion 5.00 µg/L (Approved*)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 114 measurements collected between March 20, 1984, and December 10, 2008. Of these 114 measurements, 8 were considered to be outliers because they had values greater than 7.5875 µg/L. So, the calculated criterion of 3.66 µg/L for Lake Travis was derived using a final dataset consisting of 106 chlorophyll *a* measurements collected between March 20, 1984, and December 10, 2008, all of which were equal to or below 7.2 µg/L. Rather than adopt the calculated criterion of 3.66 µg/L, TCEQ set the chlorophyll *a* criterion for Lake Travis at a minimum default criterion of 5.00 µg/L, a level that TCEQ explains could generally be historically quantified by laboratory chemical analyses. EPA's review of TCEQ's use of the minimum default criterion for Lake Travis is described further below.

Review of Use of Minimum Default Criterion: As noted above, the calculated chlorophyll *a* criterion for Lake Travis is is 3.66 µg/L. Of the 106 measurements used in the derivation of this criterion, 29 measurements (27%) were reported as less than the minimum reporting limits. The analytical method for 15 of these measurements used a LOQ of 5 µg/L and seven other measurements used a MDL/MAL of 6 µg/L or 2 µg/L or a LOQ of 5 µg/L or 2 µg/L. Where a MDL of 1 µg/L was reported, TCEQ retained that measurement value in the criterion derivation, rather than substituting a value of half the MDL. The

dataset for Lake Travis also included three samples reported at less than an MDL/MAL of 0.5 µg/L. In this case, a value of 1 µg/L was used for derivation of the criterion.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Lake Travis.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Lake Travis:

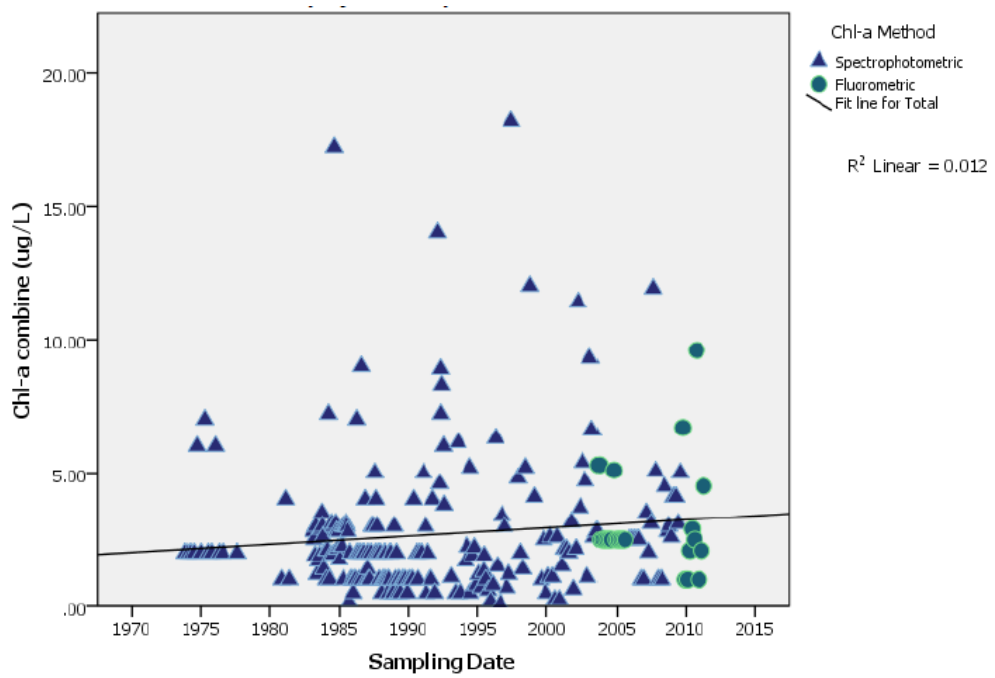
Year	Parameter	Assessment Unit	Assessment Unit Description
2010	DO	1404_04	Lakeway area, from Hurst Creek arm upstream to the confluence with Cow Creek
2006	DO	1404_05	From the confluence with Cow Creek upstream to the confluence
2008	DO	1404_05	From the confluence with Cow Creek upstream to the confluence of the Pedernales River
2010	DO	1404_05	From the confluence with Cow Creek upstream to the confluence of the Pedernales River Arm
2006	DO	1404_06	From the confluence with the Pedernales River Arm upstream to Muleshoe Bend
2008	DO	1404_06	From the confluence with the Pedernales River upstream to Muleshoe Bend
2010	DO	1404_06	From the confluence with the Pedernales River Arm upstream to Muleshoe Bend
2006	DO	1404_07	From Muleshoe Bend upstream to the confluence with Hickory Creek
2010	DO	1404_10	Bee Creek Arm

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Lake Travis in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Lake Travis was not sampled as part of the 2007 NLA.

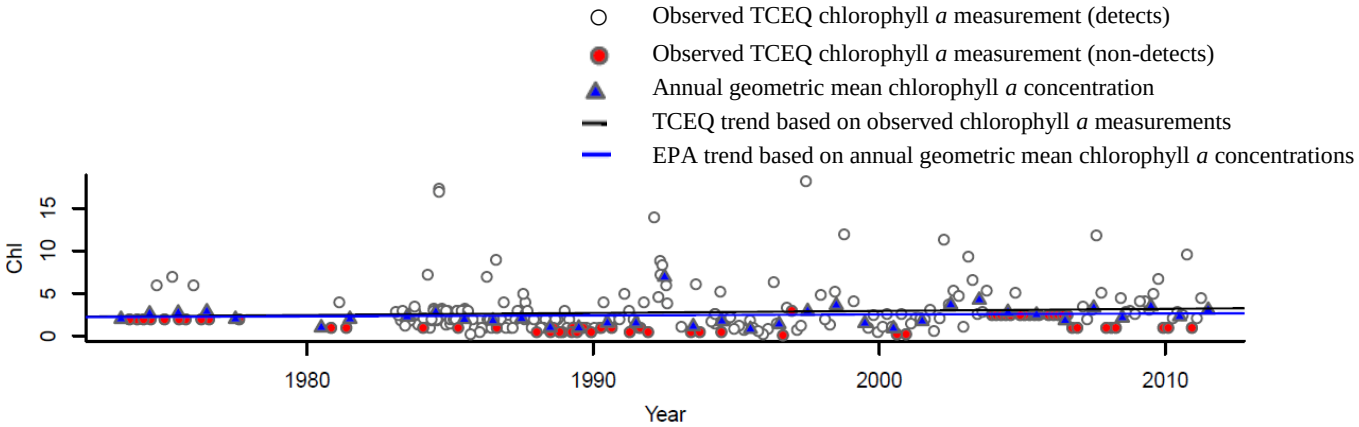
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ did not identify any statistically significant increasing trends in chlorophyll *a* concentrations for Lake Travis (see Figure 7).

Figure 7. Chlorophyll *a* Trend for Lake Travis Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Lake Travis based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 8). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Lake Travis, the magnitude of the slope of this increasing trend was relatively small at 0.011 µg/L chlorophyll *a*/year.

Figure 8. Chlorophyll *a* Trends for Lake Travis Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Lake Travis was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Lake Travis between the 2000 and 2010 reporting cycles. According to the report, a

Carlson's TSI value of 41.28 was determined for the 2010 reporting cycle for Lake Travis. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 3.07 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Lake Travis was mesotrophic for both the 2000 and 2010 reporting cycles.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Lake Travis, the chlorophyll *a* criterion is below 30 µg/L and 0% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Lake Travis, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of Lake Travis. Reservoir-specific data and information described above indicates a mesotrophic classification for this reservoir, with a relatively small rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.011 µg/L chlorophyll *a*/year) and an increasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. EPA strongly considered the relatively small rate of increasing chlorophyll *a*, the lack of a statistically significant increasing trend, and the trophic classification of mesotrophic in both 2000 and 2010, when evaluating the adoption of the default criterion for Lake Travis. Additionally, TCEQ did not identify any CWA §303(d) listings for pH or DO for Lake Travis. While TCEQ did identify nine concerns for DO in Lake Travis during the 2006 through 2010 reporting cycles, none of these concerns were associated with the assessment unit encompassing the main pool near the dam, and TCEQ did not identify concerns for any other nutrient-enrichment related indicators or any nutrient indicators. Further, none of the measurements in the underlying chlorophyll *a* dataset available for Lake Travis were greater than 30 µg/L. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 5.00 µg/L applicable to Lake Travis is protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

5. <u>Lake Georgetown, Segment 1249, Chlorophyll *a* Criterion 5.00 µg/L (Approved*)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 72 measurements collected between August 22, 1990, and September 16, 2008. Of these 72 measurements, 5 were considered to be outliers because they had values greater than 7.41875 µg/L. So, the calculated criterion of 3.87 µg/L for Lake Georgetown was derived using a final dataset consisting of 67 chlorophyll *a* measurements collected between August 22, 1990, and August 7, 2008, all of which were equal to or below 7.2 µg/L. Rather than adopt the calculated criterion of 3.87 µg/L, TCEQ set the chlorophyll *a* criterion for Lake Georgetown at a minimum default criterion of 5.00 µg/L, a level that TCEQ explains could generally be historically quantified by laboratory chemical analyses. EPA's review of TCEQ's use of the minimum default criterion for Lake Georgetown is described further below.

Review of Use of Minimum Default Criterion: As noted above, the calculated chlorophyll *a* criterion for Lake Georgetown is is 3.87 µg/L. Of the 67 measurements used in the derivation of this criterion, 38 measurements (57%) were reported as less than the minimum reporting limits. The analytical method for

24 of these measurements used a LOQ of 3.3 µg/L and 14 other measurements used a MDL/MAL of 2 µg/L or 1 µg/L, or a LOQ of 5 µg/L or 3 µg/L. Where a MDL of 1 µg/L was reported, TCEQ retained that measurement value in the criterion derivation, rather than substituting a value of half the MDL.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Lake Georgetown.

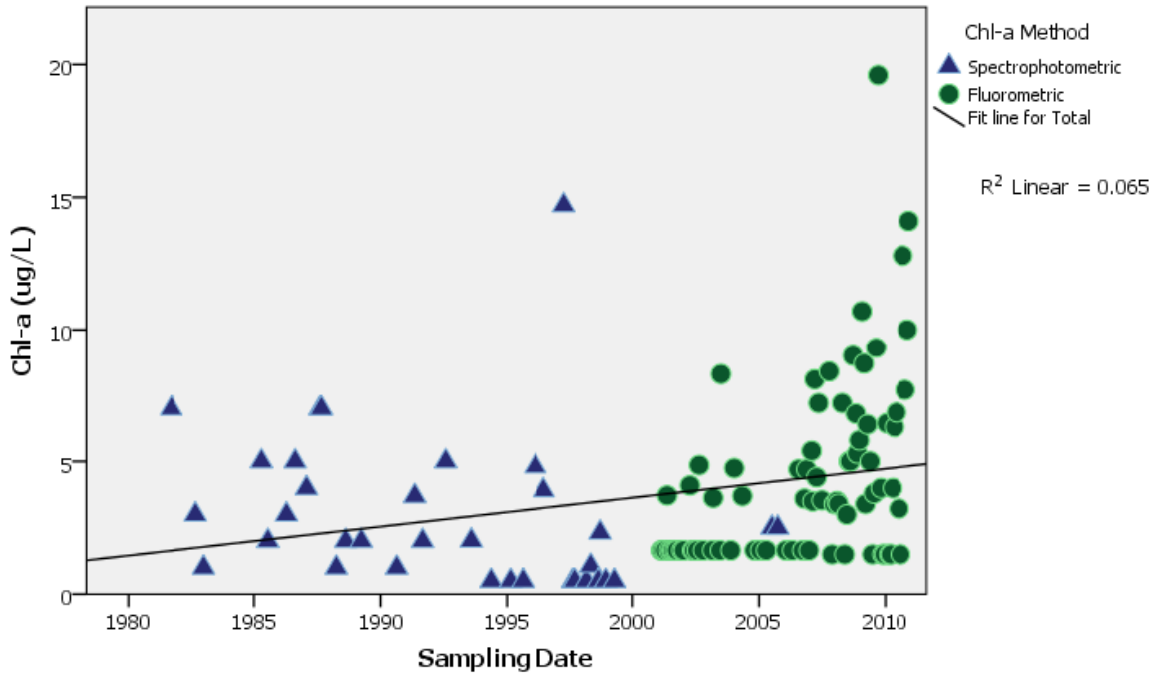
Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, no water quality concerns for any nutrient or nutrient enrichment-related indicators were identified for Lake Georgetown.

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Lake Georgetown in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Lake Georgetown was not sampled as part of the 2007 NLA.

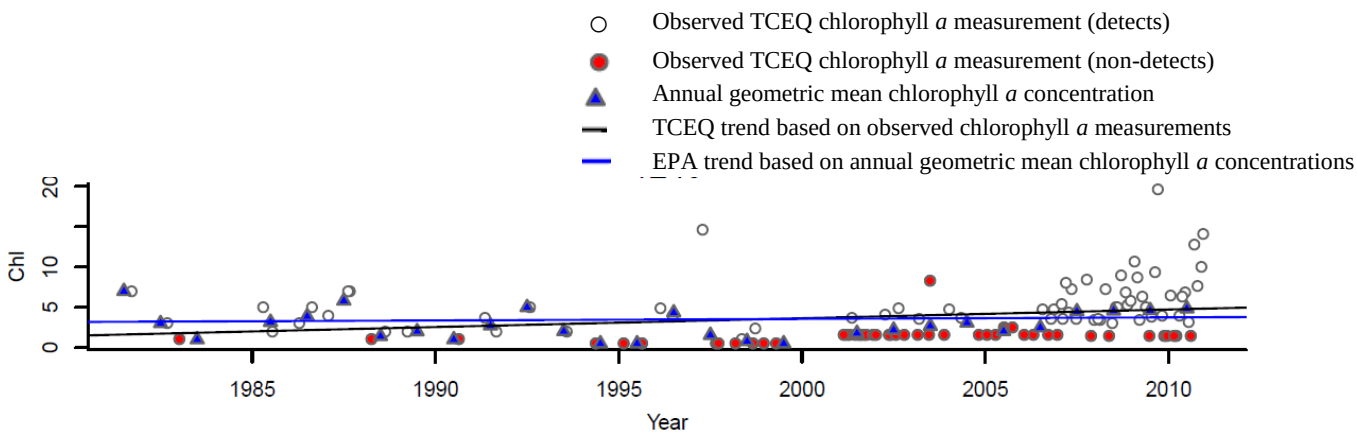
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 112 chlorophyll *a* measurements collected from Lake Georgetown between 1981 and 2010 (see Figure 9). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Lake Georgetown. Based upon the supporting information provided by TCEQ, a shift in methodology does appear to have occurred for this dataset in 2001 (most data after 2001 was collected using the fluorometric method rather than the spectrophotometric method). Thirty-four chlorophyll *a* measurements were made using the spectrophotometric method, with 14 of these measurements (~41%) being reported as less than the minimum reporting limits. Seventy-eight measurements were made using the fluorometric method, with 33 of these measurements (~42%) being reported as less than the minimum reporting limits. When TCEQ analyzed trends for each of these datasets separately, the chlorophyll *a* data collected using the spectrophotometric method did not show a statistically significant increasing trend, while the chlorophyll *a* data collected using the fluorometric method did show a statistically significant increasing trend. In further analyzing the fluorometric method dataset, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) did not affect the statistical significance of this chlorophyll *a* trend to such a degree that the trend became statistically insignificant. Therefore, EPA believes that this increasing trend for Lake Georgetown is statistically significant.

Figure 9. Chlorophyll *a* Trend for Lake Georgetown Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Lake Georgetown based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 10). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Lake Georgetown, the magnitude of the slope of this increasing trend was relatively small at 0.019 µg/L chlorophyll *a*/year.

Figure 10. Chlorophyll *a* Trends for Lake Georgetown Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Lake Georgetown was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Lake Georgetown between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 34.58 was determined for the 2010 reporting cycle for Lake Georgetown.

This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 2.48 points lower than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Lake Georgetown Lake shifted from a mesotrophic classification for the 2000 reporting cycle to an oligotrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Lake Georgetown, the chlorophyll *a* criterion is below 30 µg/L and 0% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Lake Georgetown, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of Lake Georgetown. Reservoir-specific data and information described above indicates a worst-case mesotrophic classification for this reservoir. While a statistically significant increasing trend in chlorophyll *a* concentration was identified based on EPA's review of TCEQ's trend analysis, the rate of chlorophyll *a* accumulation was relatively small based on EPA's trend analysis (slope = 0.019 µg/L chlorophyll *a*/year). EPA strongly considered the relatively small rate of increasing chlorophyll *a*, the large portion of the dataset measured below minimum reporting limits, and the shift in trophic classification from mesotrophic in 2000 to oligotrophic in 2010, when evaluating the adoption of the default criterion for Lake Georgetown. Additionally, TCEQ did not identify any CWA §303(d) listings for pH or DO for Lake Georgetown, nor did it identify any concerns for nutrient or nutrient-enrichment related indicators. Further, none of the measurements in the underlying chlorophyll *a* dataset available for Lake Georgetown were greater than 30 µg/L. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 5.00 µg/L applicable to Lake Georgetown is protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

6. <u>Canyon Lake, Segment 1805, Chlorophyll *a* Criterion 5.00 µg/L (Approved*)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 56 measurements collected between June 4, 2001, and November 24, 2008. Of these 56 measurements, 2 were considered to be outliers because they had values greater than 10.4 µg/L. So, the calculated criterion of 4.11 µg/L for Canyon Lake was derived using a final dataset consisting of 54 chlorophyll *a* measurements collected between June 4, 2001, and November 24, 2008, all of which were equal to or below 5 µg/L. Rather than adopt the calculated criterion of 4.11 µg/L, TCEQ set the chlorophyll *a* criterion for Canyon Lake at a minimum default criterion of 5.00 µg/L, a level that TCEQ explains could generally be historically quantified by laboratory chemical analyses. EPA's review of TCEQ's use of the minimum default criterion for Canyon Lake is described further below.

Review of Use of Minimum Default Criterion: As noted above, the calculated chlorophyll *a* criterion for Canyon Lake is 4.11 µg/L. Of the 54 measurements used in the derivation of this criterion, 39 measurements (72%) were reported as less than the minimum reporing limits. The analytical method for 16 of these measurements used a LOQ of 10 µg/L and the remaining 23 samples were analyzed with either a LOQ of 5 µg/L, 3 µg/L or 1 ug/l (data collected before 2000). Where a MDL of 1 µg/L was

reported, TCEQ retained that measurement value in the criterion derivation, rather than substituting a value of half the MDL.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Canyon Lake.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Canyon Lake:

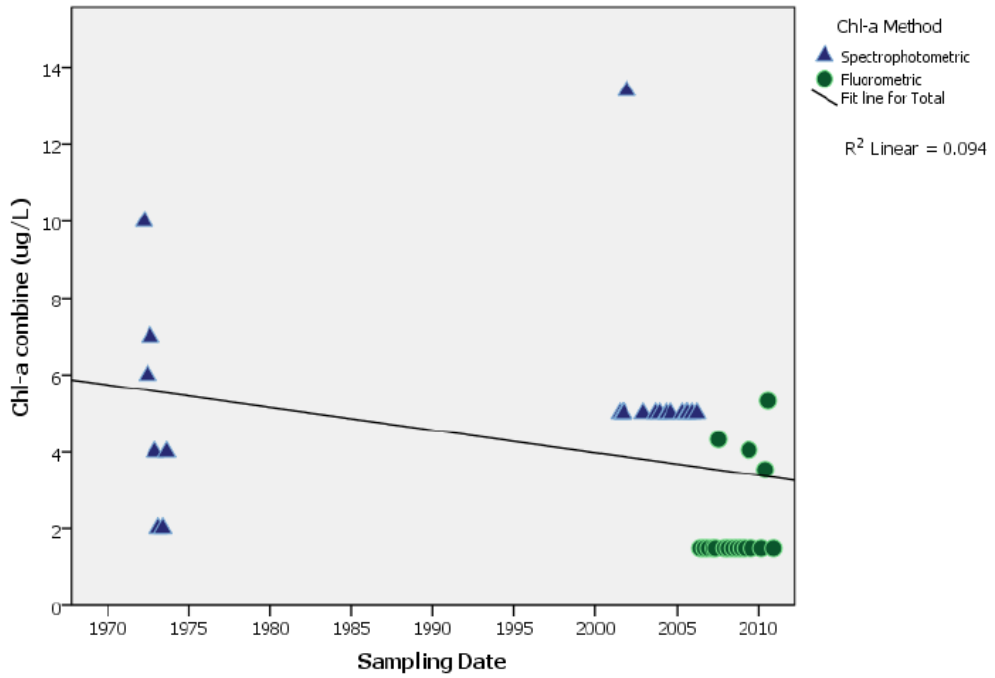
Year	Parameter	Assessment Unit	Assessment Unit Description
2008	OP	1805_02	North end of Crane's Mill Park peninsula to south end of Canyon Park
2006	NO3-N	1805_03	Upper end of segment
2008	OP	1805_03	Upper end of segment
2008	OP	1805_04	Lower end of reservoir from dam upstream to Canyon Park

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Canyon Lake in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Canyon Lake was not sampled as part of the 2007 NLA.

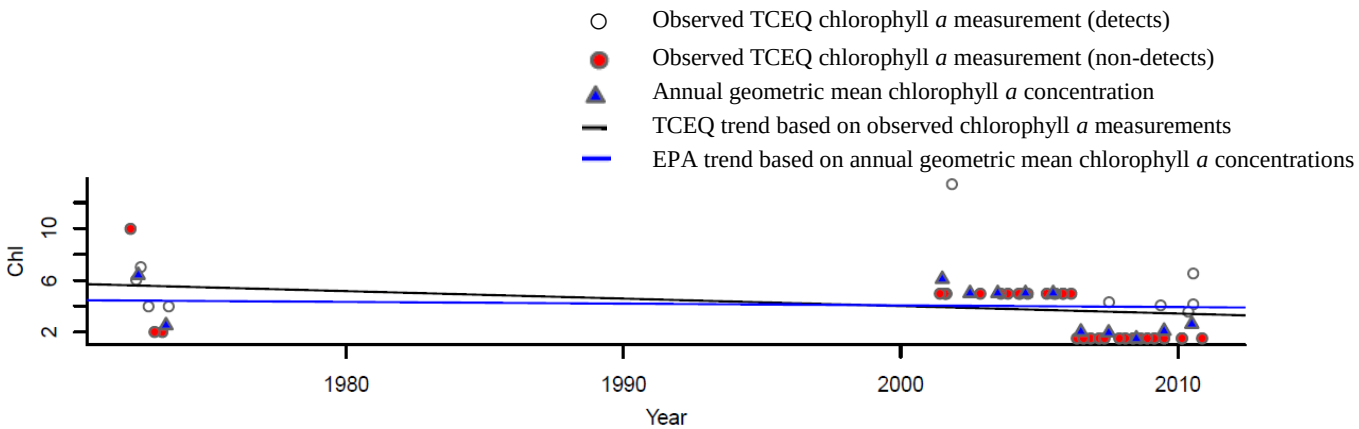
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ did not identify any statistically significant increasing trends in chlorophyll *a* concentrations for Canyon Lake (see Figure 11).

Figure 11. Chlorophyll *a* Trend for Canyon Lake Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Canyon Lake based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 12). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Canyon Lake, the trend was decreasing with a slope magnitude of -0.013 µg/L chlorophyll *a*/year.

Figure 12. Chlorophyll *a* Trends for Canyon Lake Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Canyon Lake was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Canyon Lake between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 47.36 was determined for the 2010 reporting cycle for Canyon Lake. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 11.06 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Canyon Lake shifted from a mesotrophic classification for the 2000 reporting cycle to a eutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Canyon Lake, the chlorophyll *a* criterion is below 30 µg/L and 0% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Canyon Lake, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of Canyon Lake. Reservoir-specific data and information described above indicates a mesotrophic classification for Canyon Lake in the 2000 reporting cycle with a shift to a eutrophic classification in the 2010 reporting cycle, though EPA also noted that the Carlson's chlorophyll *a* TSI value of 47.36 determined for the 2010 reporting cycle is only 2.36 points above the mesotrophic-eutrophic classification boundary identified in TCEQ's trophic classification report (i.e., chlorophyll *a* TSI >45 is considered eutrophic). Also, the shift to a eutrophic classification appears

inconsistent with EPA's and TCEQ's trend analysis results. For example, Canyon Lake showed a decreasing rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = -0.013 µg/L chlorophyll *a*/year) and a statistically significant decreasing trend in chlorophyll *a* concentration based on EPA's review of TCEQ's trend analysis. EPA strongly considered the decreasing chlorophyll *a* trends in EPA's and TCEQ's trend analyses and the large portion of data (30%) measured with a LOQ of 10 µg/L, when evaluating the adoption of the default criterion for Canyon Lake. Additionally, TCEQ did not identify any CWA §303(d) listings for pH or DO for Canyon Lake. While TCEQ did identify four concerns for nutrients (NO3-N and OP) in Canyon Lake in the 2006 and 2008 reporting cycles, these concerns were not repeating. Further, none of the measurements in the underlying chlorophyll *a* dataset available for Canyon Lake were greater than 30 µg/L. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 5.00 µg/L applicable to Canyon Lake is protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

7. Greenbelt Lake, Segment 0223, Chlorophyll *a* Criterion 5.00 µg/L (Approved*)

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 44 measurements collected between February 6, 1990, and November 13, 2008. Of these 44 measurements, 1 was considered to be an outlier because it had a value greater than 10.25 µg/L. So, the calculated criterion of 4.59 µg/L for Greenbelt Lake was derived using a final dataset consisting of 43 chlorophyll *a* measurements collected between February 6, 1990, and November 13, 2008, all of which were equal to or below 6.2 µg/L. Rather than adopt the calculated criterion of 4.59 µg/L, TCEQ set the chlorophyll *a* criterion for Greenbelt Lake at a minimum default criterion of 5.00 µg/L, a level that TCEQ explains could generally be historically quantified by laboratory chemical analyses. EPA's review of TCEQ's use of the minimum default criterion for Greenbelt Lake is described further below.

Review of Use of Minimum Default Criterion: As noted above, the calculated chlorophyll *a* criterion for Greenbelt Lake is 4.59 µg/L. Of the 43 measurements used in the derivation of this criterion, 22 measurements (51%) were reported as less than the minimum reporting limits. The analytical method for 12 of these measurements used a LOQ of 10 µg/L and the remaining ten samples were analyzed with either a LOQ of 3 µg/L or or a MDL/MAL of 1 ug/l. Where a MDL of 1 µg/L was reported, TCEQ retained that measurement value in the criterion derivation, rather than substituting a value of half the MDL.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Greenbelt Lake.

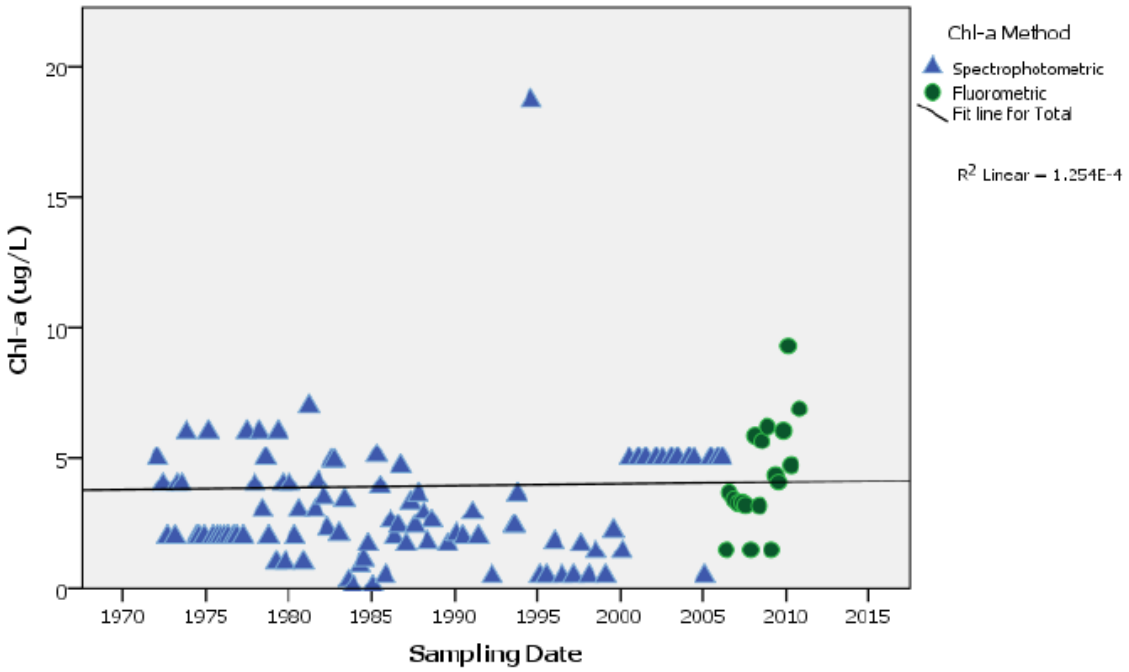
Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, no water quality concerns for any nutrient or nutrient enrichment-related indicators were identified for Greenbelt Lake.

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Greenbelt Lake in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Greenbelt Lake was not sampled as part of the 2007 NLA.

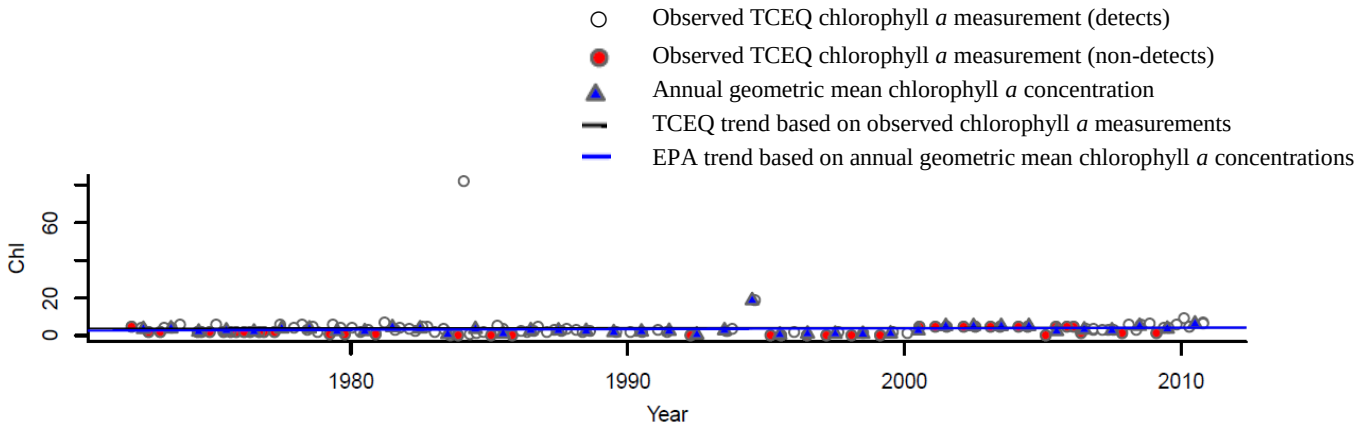
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ did not identify a statistically significant increasing trend using 115 chlorophyll *a* measurements collected from Greenbelt Lake between 1972 and 2010 (see Figure 13). However, when TCEQ analyzed trends separately for chlorophyll *a* data collected using the spectrophotometric method and chlorophyll *a* data collected using the fluorometric data, the chlorophyll *a* data collected using the fluorometric method did show a statistically significant increasing trend. Because TCEQ noted that changes in reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the fluorometric method dataset for Greenbelt Lake. Eighteen chlorophyll *a* measurements were made using the fluorometric method, with 3 of these measurements (~17%) reported as being less than the reporting limits. In further analyzing the fluorometric method dataset, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) did not affect the statistical significance of this chlorophyll *a* trend to such a degree that the trend became statistically insignificant. Therefore, EPA believes that this increasing trend for Greenbelt Lake is statistically significant.

Figure 13. Chlorophyll *a* Trend for Greenbelt Lake Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Greenbelt Lake based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 14). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Greenbelt Lake, the magnitude of the slope of this increasing trend was relatively small at 0.039 µg/L chlorophyll *a*/year.

Figure 14. Chlorophyll *a* Trends for Greenbelt Lake Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Greenbelt Lake was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Greenbelt Lake between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 44.3 was determined for the 2010 reporting cycle for Greenbelt Lake. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 7.98 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Greenbelt Lake was mesotrophic for both the 2000 and 2010 reporting cycles.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Greenbelt Lake, the chlorophyll *a* criterion is below 30 µg/L but 1% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Greenbelt Lake, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of Greenbelt Lake. Reservoir-specific data and information described above indicates a mesotrophic classification for this reservoir. While a statistically significant increasing trend in chlorophyll *a* concentration was identified based on EPA's review of TCEQ's trend analysis, the rate of chlorophyll *a* accumulation was relatively small based on EPA's trend analysis (slope = 0.039 µg/L chlorophyll *a*/year). EPA strongly considered the relatively small rate of increasing chlorophyll *a*, the large portion of data (28%) measured with a LOQ of 10 µg/L, and the trophic classification of mesotrophic in both 2000 and 2010, when evaluating the adoption of the default criterion for Greenbelt Lake. Additionally, TCEQ did not identify any CWA §303(d) listings for pH or DO for Greenbelt Lake, nor did it identify any concerns for nutrient or nutrient-enrichment related indicators. Further, only 1% of the measurements in the underlying chlorophyll *a* dataset available for Greenbelt Lake were greater than 30 µg/L. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 5.00 µg/L applicable to Greenbelt Lake is protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

8. Lake Cisco, Segment 1234, Chlorophyll *a* Criterion 5.00 µg/L (Approved*)

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 43 measurements collected between September 5, 1973, and August 25, 2008. Of these 43 measurements, none were considered to be outliers because none had values greater than 9.5 µg/L. So, the calculated criterion of 4.64 µg/L for Lake Cisco was derived using a final dataset consisting of 43 chlorophyll *a* measurements collected between September 5, 1973, and August 25, 2008, all of which were equal to or below 8.6 µg/L. Rather than adopt the calculated criterion of 4.64 µg/L, TCEQ set the chlorophyll *a* criterion for Lake Cisco at a minimum default criterion of 5.00 µg/L, a level that TCEQ explains could generally be historically quantified by laboratory chemical analyses. EPA's review of TCEQ's use of the minimum default criterion for Lake Cisco is described further below.

Review of Use of Minimum Default Criterion: As noted above, the calculated chlorophyll *a* criterion for Lake Cisco is 4.64 µg/L. Of the 43 measurements used in the derivation of this criterion, 27 measurements (63%) were reported as less than the minimum reporting limits. The analytical method for 10 of these measurements used a LOQ of 10 µg/L and the remaining 17 samples were analyzed with either a LOQ of 3 µg/L or or an MDL/MAL of 4 µg/L or 1 ug/l. Where a MDL of 1 µg/L was reported, TCEQ retained that measurement value in the criterion derivation, rather than substituting a value of half the MDL.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Lake Cisco.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, no water quality concerns for any nutrient or nutrient enrichment-related indicators were identified for Lake Cisco.

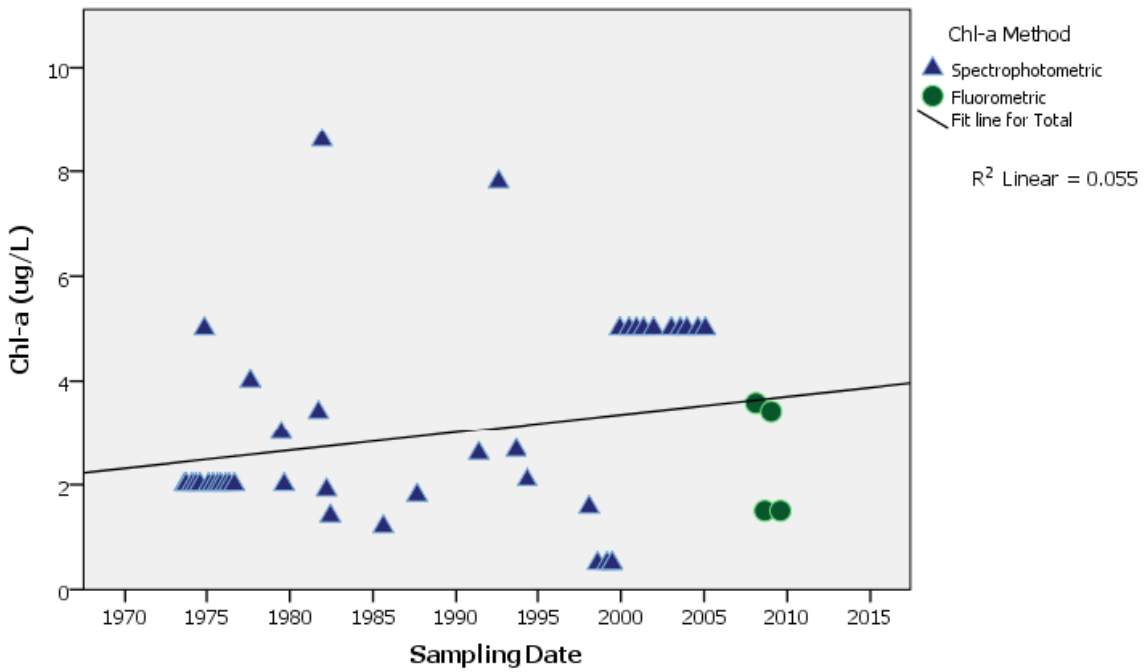
Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Lake Cisco in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Lake Cisco was sampled one time as part of the NLA. The chlorophyll *a* concentration measured during sampling was 3.63 µg/L, indicating a low risk of exposure based on the chlorophyll *a* thresholds used in the NLA study. The microcystin concentration during sampling was below the reporting limit of 0.1 µg/L, indicating a low risk of exposure based on the microcystin thresholds used in the NLA study. The cyanobacteria cell count during sampling was less than 20,000 cells per milliliter, indicating a low risk of exposure based on the cyanobacteria thresholds used in the NLA study.

TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ did not identify a statistically significant increasing trend using 45 chlorophyll *a* measurements collected from Lake Cisco between 1973 and 2009 (see Figure 15). However, when TCEQ analyzed trends separately for chlorophyll *a* data collected using the spectrophotometric method and chlorophyll *a* data collected using the fluorometric data, the chlorophyll *a* data collected using the spectrophotometric method did show a statistically significant increasing trend. Because TCEQ noted that changes in reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the spectrophotometric method dataset for Lake Cisco. Forty-one chlorophyll *a* measurements were made using the spectrophotometric method, with 26 of these measurements (~63%) reported as being less than the reporting limits. In further analyzing the spectrophotometric method

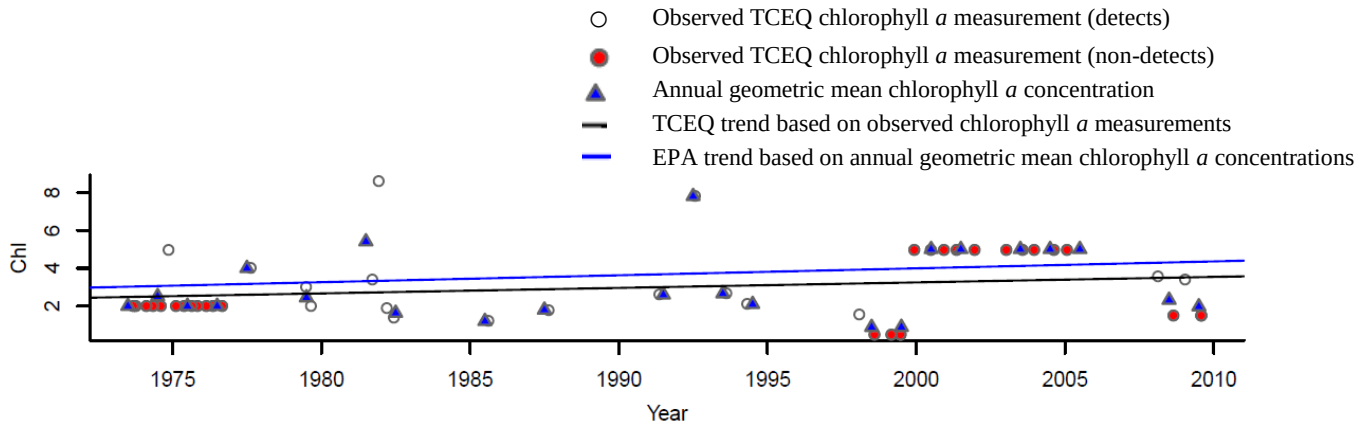
dataset, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) affected the statistical significance of this chlorophyll *a* trend to such a degree that the increasing trend for Lake Cisco was no longer considered statistically significant.

Figure 15. Chlorophyll *a* Trend for Lake Cisco Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Lake Cisco based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 16). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Lake Cisco, the magnitude of the slope of this increasing trend was relatively small at 0.037 µg/L chlorophyll *a*/year.

Figure 16. Chlorophyll *a* Trends for Lake Cisco Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Lake Cisco was not included in TCEQ's report titled *Trophic Classification of Texas Reservoirs*.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Lake Cisco, the chlorophyll *a* criterion is below 30 µg/L and 0% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Lake Cisco, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of Lake Cisco. While trophic state classification information was not available for Lake Cisco, reservoir-specific data and information described above indicates a relatively small rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.037 µg/L chlorophyll *a*/year) and an increasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. EPA strongly considered the relatively small rate of increasing chlorophyll *a*, the lack of a statistically significant increasing trend in chlorophyll *a* concentration, and the relatively large portion of data (24%) measured with a LOQ of 10 µg/L, when evaluating the adoption of the default criterion for Lake Cisco. Additionally, TCEQ did not identify any CWA §303(d) listings for pH or DO for Lake Cisco, nor did it identify any concerns for nutrient or nutrient-enrichment related indicators. Further, 2007 NLA data indicated a low risk of exposure based on chlorophyll *a*, microcystin, and cyanobacteria thresholds, and none of the measurements in the underlying chlorophyll *a* dataset available for Lake Cisco were greater than 30 µg/L. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 5.00 µg/L applicable to Lake Cisco is protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

9. Bridgeport Reservoir, Segment 0811, Chlorophyll *a* Criterion 5.32 µg/L (Approved*)

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 218 measurements collected between April 5, 1972, and November 4, 2008. Of these 218 measurements, 7 were considered to be outliers because they had values greater than 9.95 µg/L. So, the criterion was derived using a final dataset consisting of 211 chlorophyll *a* measurements collected between April 5, 1972, and October 8, 2008, all of which were equal to or below 9.5 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Bridgeport Reservoir.

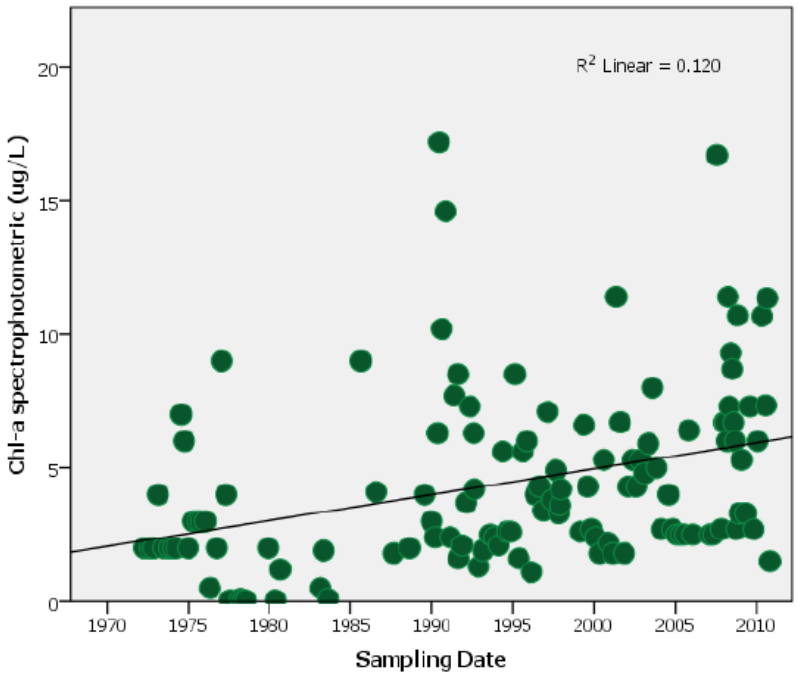
Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, no water quality concerns for any nutrient or nutrient enrichment-related indicators were identified for Bridgeport Reservoir.

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Bridgeport Reservoir in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Bridgeport Reservoir was not sampled as part of the 2007 NLA.

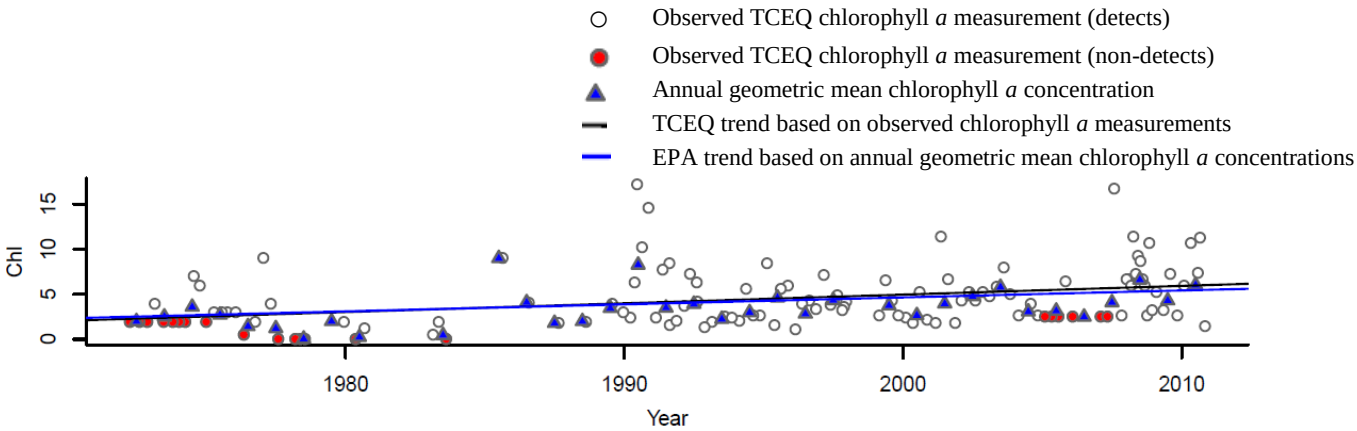
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 124 chlorophyll *a* measurements collected from Bridgeport Reservoir between 1972 and 2010 (see Figure 17). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Bridgeport Reservoir. Based upon the supporting information provided by TCEQ, all of these chlorophyll *a* measurements were determined using the same method (spectrophotometric). Twenty-one of these 124 measurements (~17%) were reported as being less than the reporting limits. In further analyzing the spectrophotometric method dataset, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) did not affect the statistical significance of this chlorophyll *a* trend to such a degree that the trend became statistically insignificant. Therefore, EPA believes that this increasing trend for Bridgeport Reservoir is statistically significant.

Figure 17. Chlorophyll *a* Trend for Bridgeport Reservoir Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Bridgeport Reservoir based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 18). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Bridgeport Reservoir, the magnitude of the slope of this increasing trend was relatively small at 0.077 µg/L chlorophyll *a*/year.

Figure 18. Chlorophyll *a* Trends for Bridgeport Reservoir Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Bridgeport Reservoir was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Bridgeport Reservoir between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 42.6 was determined for the 2010 reporting cycle for Bridgeport Reservoir. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 4.01 points lower than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Bridgeport Reservoir shifted from a eutrophic classification for the 2000 reporting cycle to a mesotrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Bridgeport Reservoir, the chlorophyll *a* criterion is below 30 µg/L and 0% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Bridgeport Reservoir, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of Bridgeport Reservoir. Reservoir-specific data and information described above indicates a eutrophic classification for Bridgeport Reservoir in the 2000 reporting cycle with a shift to a mesotrophic classification in the 2010 reporting cycle. This shift to an improved trophic classification appears inconsistent with EPA's and TCEQ's trend analysis results which show a statistically significant increasing trend in chlorophyll *a* concentration based on EPA's review of TCEQ's trend analysis and an increasing rate of chlorophyll *a* accumulation based on EPA's trend analysis. However, the increasing rate of chlorophyll *a* accumulation based on EPA's trend analysis was relatively small (slope = 0.077 µg/L chlorophyll *a*/year), and EPA noted that the Carlson's chlorophyll *a* TSI values determined for the 2000 and 2010 reporting cycles closely straddle the mesotrophic-eutrophic classification boundary identified in TCEQ's trophic classification report (i.e., chlorophyll *a* TSI >45 is considered eutrophic). Additionally, TCEQ did not identify any CWA §303(d) listings for pH or DO for Bridgeport Reservoir, nor did it identify any concerns for nutrient or nutrient-enrichment related indicators. Further, none of the measurements in the underlying chlorophyll *a* dataset available for Bridgeport Reservoir were greater than 30 µg/L. Based on the above information, EPA concludes that the

chlorophyll *a* criterion of 5.32 µg/L applicable to Bridgeport Reservoir is protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

10. <u>Lake Jacksonville, Segment 0614, Chlorophyll *a* Criterion 5.60 µg/L (Approved)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 42 measurements collected between between July 25, 1990, and June 3, 2008. Of these 42 measurements, 1 was considered to be an outlier because it had a value greater than 9.87875 µg/L. So, the criterion was derived using a final dataset consisting of 41 chlorophyll *a* measurements collected between between July 25, 1990, and June 3, 2008, all of which were equal to or below 6.56 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Lake Jacksonville.

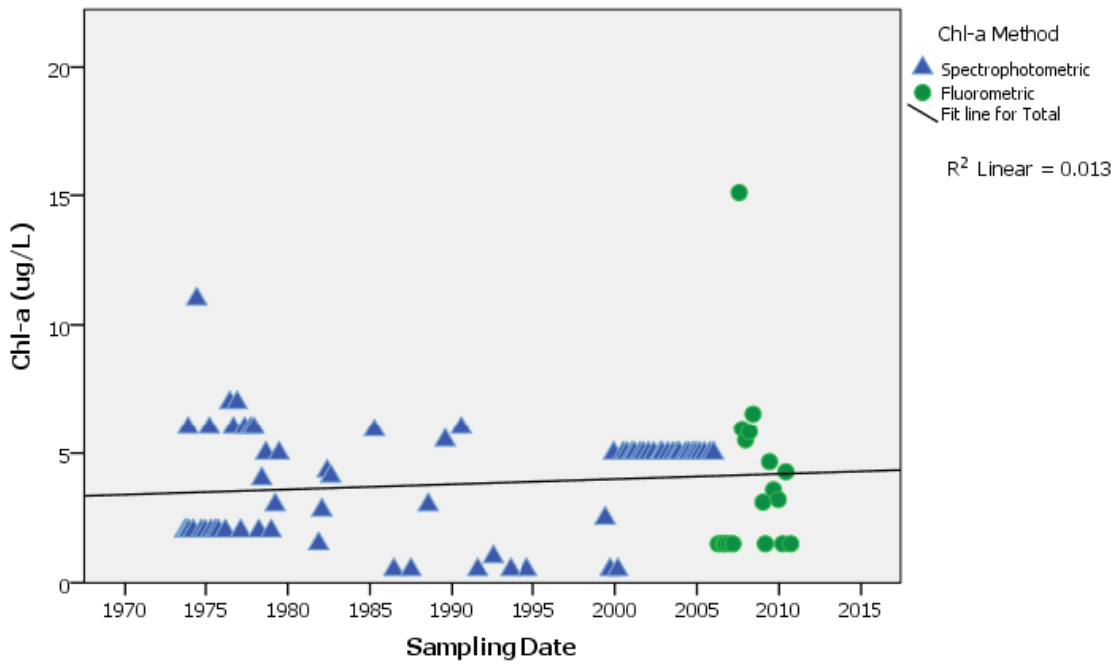
Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, no water quality concerns for any nutrient or nutrient enrichment-related indicators were identified for Lake Jacksonville.

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Lake Jacksonville in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Lake Jacksonville was sampled one time as part of the 2007 NLA. The chlorophyll *a* concentration measured during sampling was 8.43 µg/L, indicating a low risk of exposure based on the chlorophyll *a* thresholds used in the NLA study. The microcystin concentration during sampling was below the reporting limit of 0.1 µg/L, indicating a low risk of exposure based on the microcystin thresholds used in the NLA study. The cyanobacteria cell count during sampling was less than 20,000 cells per milliliter, indicating a low risk of exposure based on the cyanobacteria thresholds used in the NLA study.

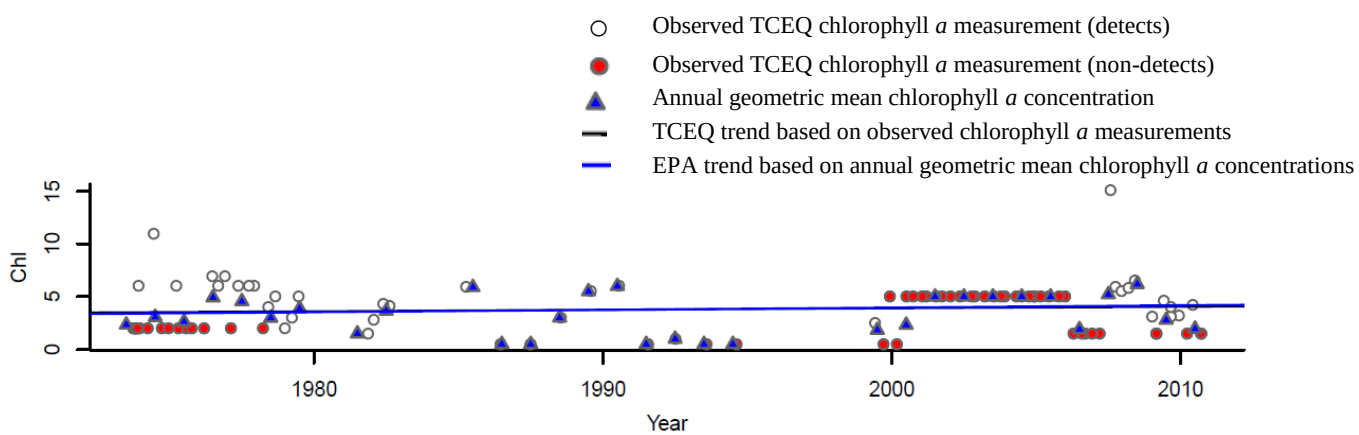
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ did not identify any statistically significant increasing trends in chlorophyll *a* concentrations for Lake Jacksonville (see Figure 19).

Figure 19. Chlorophyll *a* Trend for Lake Jacksonville Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Lake Jacksonville based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 20). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Lake Jacksonville, the magnitude of the slope of this increasing trend was relatively small at 0.022 µg/L chlorophyll *a*/year.

Figure 20. Chlorophyll *a* Trends for Lake Jacksonville Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Lake Jacksonville was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Lake Jacksonville between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 45.52 was determined for the 2010 reporting cycle for Lake Jacksonville. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water

quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 9.23 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Lake Jacksonville shifted from a mesotrophic classification for the 2000 reporting cycle to a eutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Lake Jacksonville, the chlorophyll *a* criterion is below 30 µg/L and 0% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Lake Jacksonville, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of Lake Jacksonville. Reservoir-specific data and information described above indicates a mesotrophic classification for Lake Jacksonville in the 2000 reporting cycle with a shift to a eutrophic classification in the 2010 reporting cycle, though EPA also noted that the Carlson's chlorophyll *a* TSI value of 45.52 determined for the 2010 reporting cycle is only 0.52 points above the mesotrophic-eutrophic classification boundary identified in TCEQ's trophic classification report (i.e., chlorophyll *a* TSI >45 is considered eutrophic). Reservoir-specific data and information described above indicates a relatively small rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.022 µg/L chlorophyll *a*/year) and an increasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. Additionally, TCEQ did not identify any CWA §303(d) listings for pH or DO for Lake Jacksonville, nor did it identify any concerns for nutrient or nutrient-enrichment related indicators. Further, 2007 NLA data indicated a low risk of exposure based on chlorophyll *a*, microcystin, and cyanobacteria thresholds, and none of the measurements in the underlying chlorophyll *a* dataset available for Lake Jacksonville were greater than 30 µg/L. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 5.60 µg/L applicable to Lake Jacksonville is protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

11. <u>Hubbard Creek Reservoir, Segment 1233, Chlorophyll *a* Criterion 5.61 µg/L (Approved*)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 50 measurements collected between between September 12, 1973, and November 19, 2008. Of these 50 measurements, 2 were considered to be outliers because they had values greater than 10.1375 µg/L. So, the criterion was derived using a final dataset consisting of 48 chlorophyll *a* measurements collected between between September 12, 1973, and November 19, 2008, all of which were equal to or below 8.8 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Hubbard Creek Reservoir.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Hubbard Creek Reservoir:

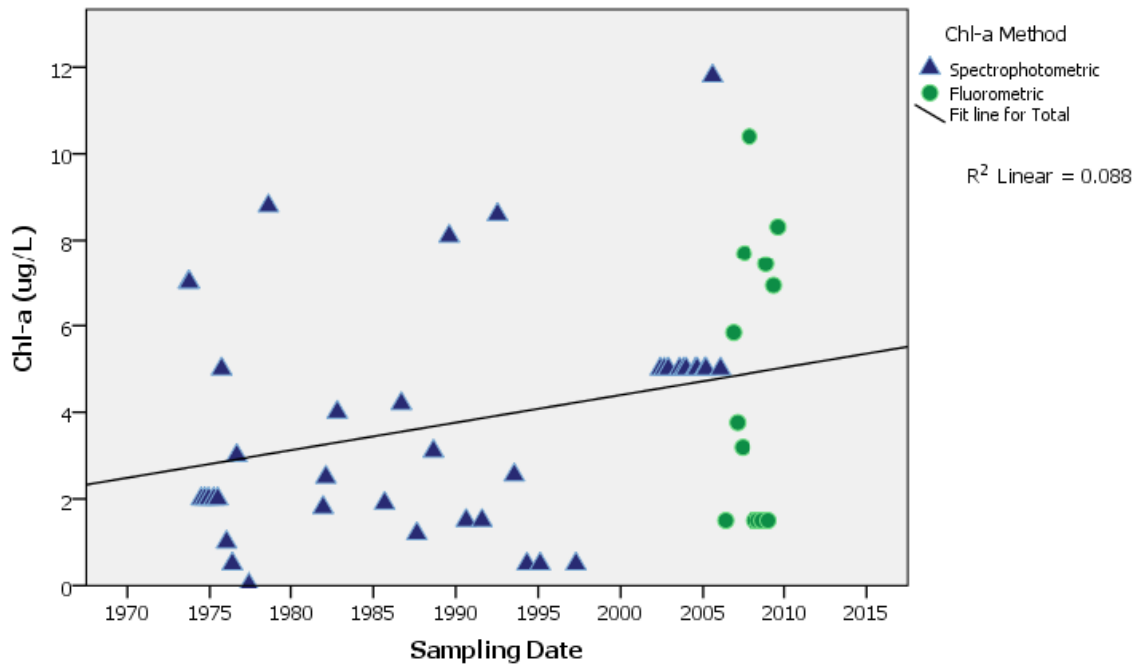
Year	Parameter	Assessment Unit	Assessment Unit Description
2008	DO	1233_02	Hubbard Creek Arm

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Hubbard Creek Reservoir in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Hubbard Creek Reservoir was not sampled as part of the 2007 NLA.

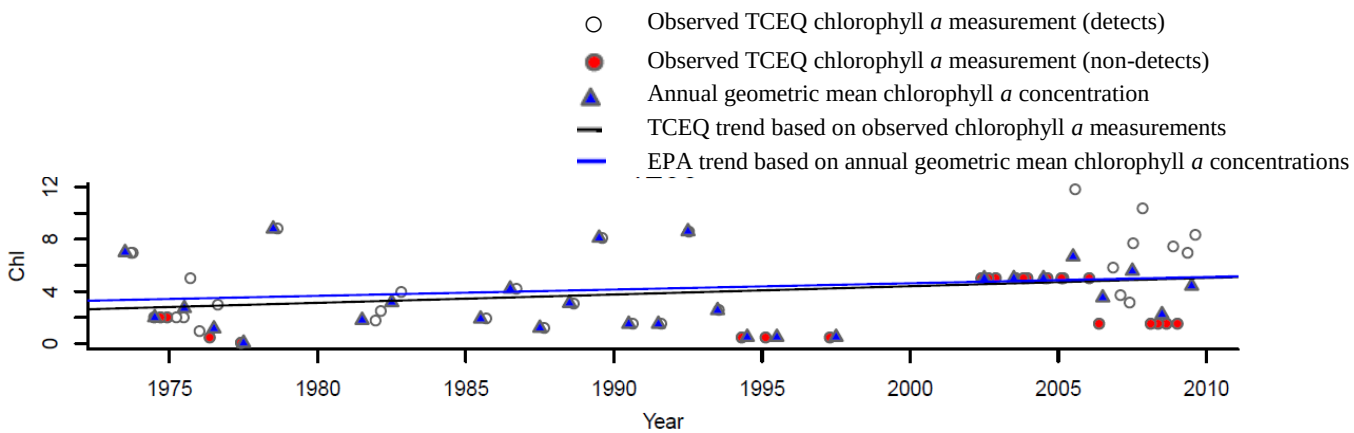
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 53 chlorophyll *a* measurements collected from Hubbard Creek Reservoir between 1973 and 2009 (see Figure 21). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Hubbard Creek Reservoir. Based upon the supporting information provided by TCEQ, a shift in methodology does appear to have occurred for this dataset in 2006 (all data after 2006 was collected using the fluorometric method rather than the spectrophotometric method). Forty chlorophyll *a* measurements were made using the spectrophotometric method, with 19 of these measurements (~48%) being reported as less than the minimum reporting limits. Thirteen measurements were made using the fluorometric method, with 5 of these measurements (~38%) being reported as less than the minimum reporting limits. When TCEQ analyzed trends for each of these datasets separately, the chlorophyll *a* data collected using the fluorometic method did not show a statistically significant increasing trend, while the chlorophyll *a* data collected using the spectrophotometric method did show a statistically significant increasing trend. In further analyzing the spectrophotometric method dataset, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) affected the statistical significance of this chlorophyll *a* trend to such a degree that the increasing trend for Hubbard Creek Reservoir was no longer considered statistically significant.

Figure 21. Chlorophyll *a* Trend for Hubbard Creek Reservoir Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Hubbard Creek Reservoir based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 22). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Hubbard Creek Reservoir, the magnitude of the slope of this increasing trend was relatively small at 0.048 µg/L chlorophyll *a*/year.

Figure 22. Chlorophyll *a* Trends for Hubbard Creek Reservoir Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Hubbard Creek Reservoir was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Hubbard Creek Reservoir between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 47.44 was determined for the 2010 reporting cycle for

Hubbard Creek Reservoir. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 9.52 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Hubbard Creek Reservoir shifted from a mesotrophic classification for the 2000 reporting cycle to a eutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Hubbard Creek Reservoir, the chlorophyll *a* criterion is below 30 µg/L and 0% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Hubbard Creek Reservoir, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of Hubbard Creek Reservoir. Reservoir-specific data and information described above indicates a mesotrophic classification for Hubbard Creek Reservoir in the 2000 reporting cycle with a shift to a eutrophic classification in the 2010 reporting cycle, though EPA also noted that the Carlson's chlorophyll *a* TSI value of 47.44 determined for the 2010 reporting cycle is only 2.44 points above the mesotrophic-eutrophic classification boundary identified in TCEQ's trophic classification report (i.e., chlorophyll *a* TSI >45 is considered eutrophic). Reservoir-specific data and information described above indicates a relatively small rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.048 µg/L chlorophyll *a*/year) and an increasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. Additionally, TCEQ did not identify any CWA §303(d) listings for pH or DO for Hubbard Creek Reservoir. While TCEQ did identify one concern for DO in Hubbard Creek Reservoir during the 2008 reporting cycle, this concern was not associated with the assessment unit encompassing the main pool near the dam, and TCEQ did not identify concerns for any other nutrient-enrichment related indicators or any nutrient indicators. Further, none of the measurements in the underlying chlorophyll *a* dataset available for Hubbard Creek Reservoir were greater than 30 µg/L. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 5.61 µg/L applicable to Hubbard Creek Reservoir is protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

12. <u>O.H. Ivie Reservoir, Segment 1433, Chlorophyll *a* Criterion 5.77 µg/L (Approved*)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 40 measurements collected between between August 27, 1991, and August 12, 2008. Of these 40 measurements, 5 were considered to be outliers because they had values greater than 9.4975 µg/L. So, the criterion was derived using a final dataset consisting of 35 chlorophyll *a* measurements collected between between August 27, 1991, and August 12, 2008, all of which were equal to or below 7.83 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for O.H. Ivie Reservoir.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles,

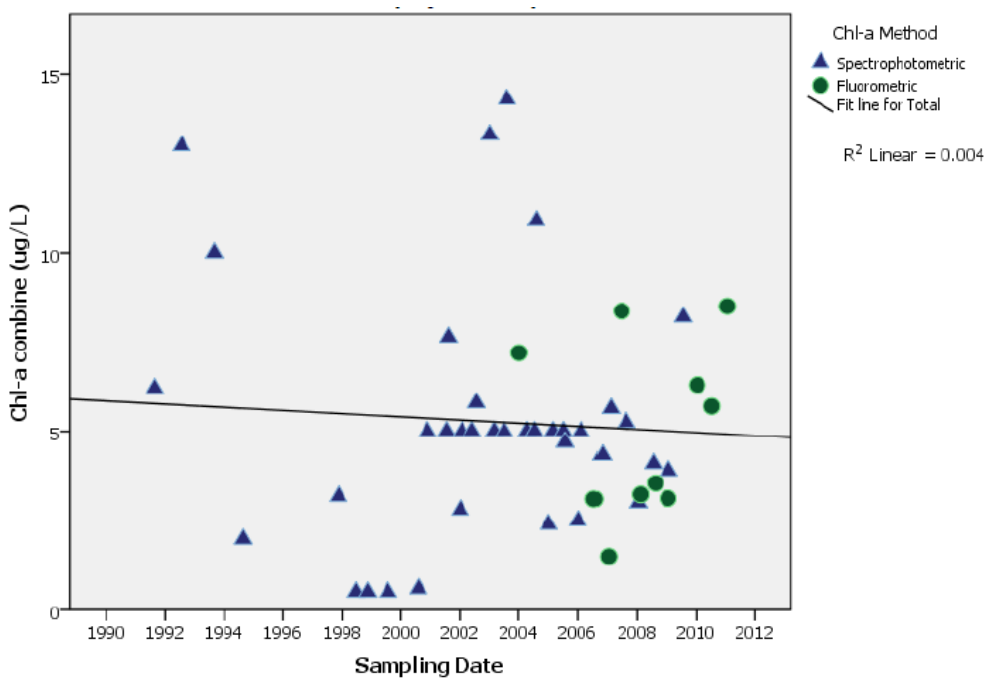
no water quality concerns for any nutrient or nutrient enrichment-related indicators were identified for O.H. Ivie Reservoir.

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for O.H. Ivie Reservoir in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: O.H. Ivie Reservoir was not sampled as part of the 2007 NLA.

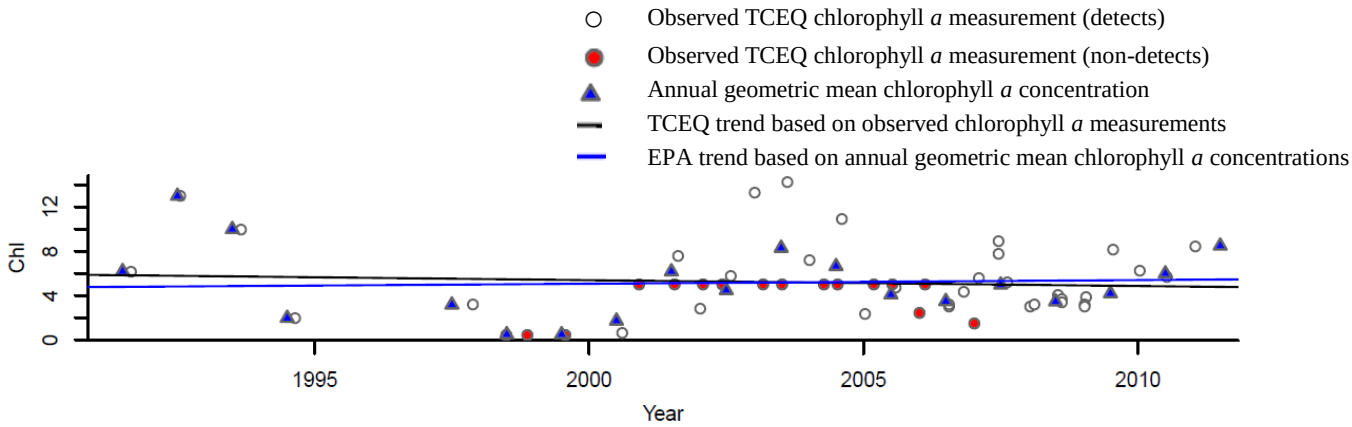
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ did not identify any statistically significant increasing trends in chlorophyll *a* concentrations for O.H. Ivie Reservoir (see Figure 23).

Figure 23. Chlorophyll *a* Trend for O.H. Ivie Reservoir Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for O.H. Ivie Reservoir based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 24). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For O.H. Ivie Reservoir, the magnitude of the slope of this increasing trend was relatively small at 0.033 µg/L chlorophyll *a*/year.

Figure 24. Chlorophyll *a* Trends for O.H. Ivie Reservoir Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: O.H. Ivie Reservoir was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for O.H. Ivie Reservoir between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 47.26 was determined for the 2010 reporting cycle for O.H. Ivie Reservoir. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 4.73 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that O.H. Ivie Reservoir shifted from a mesotrophic classification for the 2000 reporting cycle to a eutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For O.H. Ivie Reservoir, the chlorophyll *a* criterion is below 30 µg/L and 0% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for O.H. Ivie Reservoir, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of O.H. Ivie Reservoir. Reservoir-specific data and information described above indicates a mesotrophic classification for O.H. Ivie Reservoir in the 2000 reporting cycle with a shift to a eutrophic classification in the 2010 reporting cycle, though EPA also noted that the Carlson's chlorophyll *a* TSI value of 47.26 determined for the 2010 reporting cycle is only 2.26 points above the mesotrophic-eutrophic classification boundary identified in TCEQ's trophic classification report (i.e., chlorophyll *a* TSI >45 is considered eutrophic). Reservoir-specific data and information described above indicates a relatively small rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.033 µg/L chlorophyll *a*/year) and a decreasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. Additionally, TCEQ did not identify any CWA §303(d) listings for pH or DO for O.H. Ivie Reservoir, nor did it identify any concerns for nutrient or nutrient-enrichment related indicators. Further, none of the measurements in the underlying chlorophyll *a* dataset available for O.H. Ivie Reservoir were greater than 30 µg/L. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 5.77 µg/L

applicable to O.H. Ivie Reservoir is protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

13. <u>Lake Graham, Segment 1231, Chlorophyll *a* Criterion 6.07 µg/L (Approved*)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 49 measurements collected between between October 3, 1973, and November 19, 2008. Of these 49 measurements, 6 were considered to be outliers because they had values greater than 9 µg/L. So, the criterion was derived using a final dataset consisting of 43 chlorophyll *a* measurements collected between between October 3, 1973, and November 19, 2008, all of which were equal to or below 9 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Lake Graham.

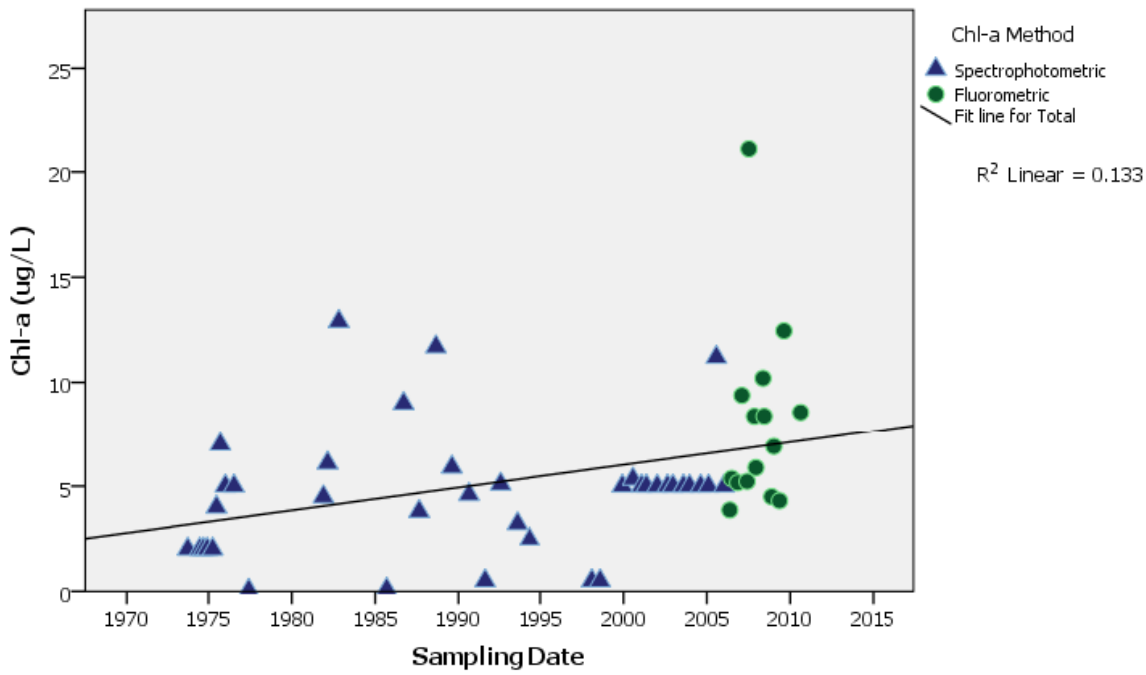
Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, no water quality concerns for any nutrient or nutrient enrichment-related indicators were identified for Lake Graham.

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Lake Graham in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Lake Graham was not sampled as part of the 2007 NLA.

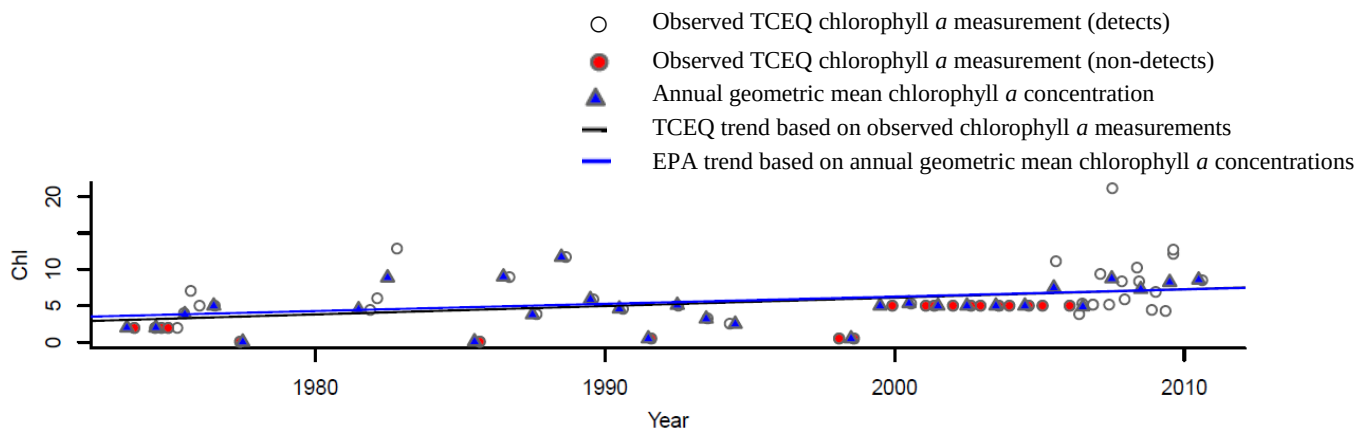
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 53 chlorophyll *a* measurements collected from Lake Graham between 1973 and 2010 (see Figure 25). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Lake Graham. Based upon the supporting information provided by TCEQ, a shift in methodology does appear to have occurred for this dataset in 2006 (all data after 2006 was collected using the fluorometric method rather than the spectrophotometric method). Thirty-eight chlorophyll *a* measurements were made using the spectrophotometric method, with 20 of these measurements (~53%) being reported as less than the minimum reporting limits. Fifteen measurements were made using the fluorometric method, with none of these measurements (0%) being reported as less than the minimum reporting limits. When TCEQ analyzed trends for each of these datasets separately, neither the chlorophyll *a* data collected using the spectrophotometric method nor the chlorophyll *a* data collected using the fluorometric method showed a statistically significant increasing trend.

Figure 25. Chlorophyll *a* Trend for Lake Graham Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Lake Graham based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 26). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Lake Graham, the magnitude of the slope of this increasing trend was relatively small at 0.099 µg/L chlorophyll *a*/year.

Figure 26. Chlorophyll *a* Trends for Lake Graham Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Lake Graham was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Lake Graham between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 47.44 was determined for the 2010 reporting cycle for Lake Graham. This value

was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 8.27 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Lake Graham shifted from a mesotrophic classification for the 2000 reporting cycle to a eutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Lake Graham, the chlorophyll *a* criterion is below 30 µg/L and 0% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Lake Graham, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of Lake Graham. Reservoir-specific data and information described above indicates a mesotrophic classification for Lake Graham in the 2000 reporting cycle with a shift to a eutrophic classification in the 2010 reporting cycle, though EPA also noted that the Carlson's chlorophyll *a* TSI value of 47.44 determined for the 2010 reporting cycle is only 2.44 points above the mesotrophic-eutrophic classification boundary identified in TCEQ's trophic classification report (i.e., chlorophyll *a* TSI >45 is considered eutrophic). Reservoir-specific data and information described above indicates a relatively small rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.099 µg/L chlorophyll *a*/year) and an increasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. Additionally, TCEQ did not identify any CWA §303(d) listings for pH or DO for Lake Graham, nor did it identify any concerns for nutrient or nutrient-enrichment related indicators. Further, none of the measurements in the underlying chlorophyll *a* dataset available for Lake Graham were greater than 30 µg/L. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 6.07 µg/L applicable to Lake Graham is protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

14. <u>Lake Coleman, Segment 1419, Chlorophyll *a* Criterion 6.07 µg/L (Approved*)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 55 measurements collected between between November 13, 1973, and August 13, 2008. Of these 55 measurements, 1 was considered to be an outlier because it had a value greater than 10.625 µg/L. So, the criterion was derived using a final dataset consisting of 54 chlorophyll *a* measurements collected between between November 13, 1973, and August 13, 2008, all of which were equal to or below 10.4 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Lake Coleman.

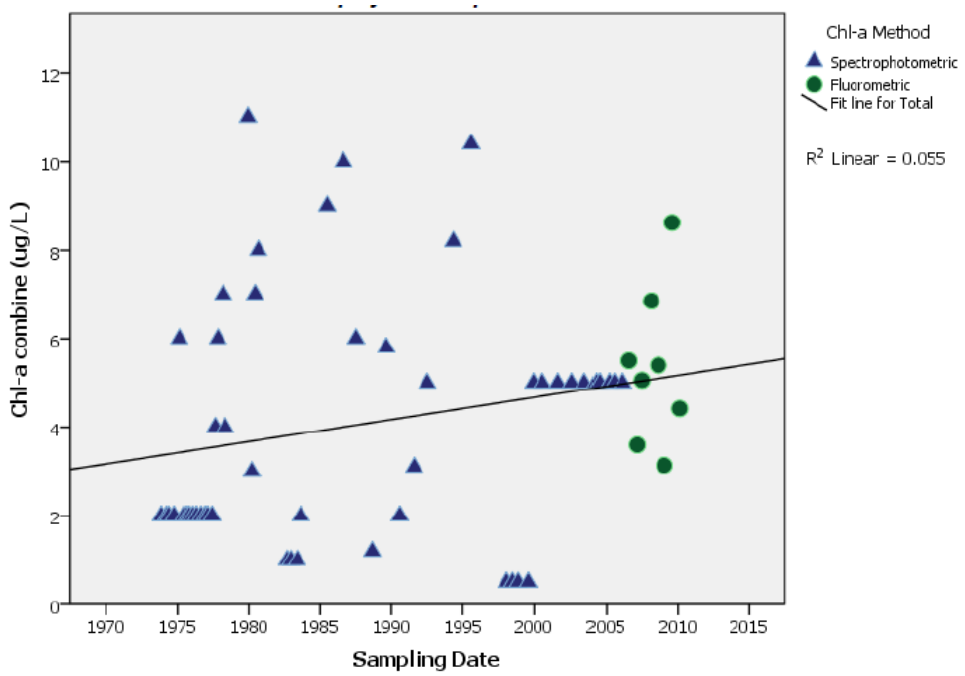
Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, no water quality concerns for any nutrient or nutrient enrichment-related indicators were identified for Lake Coleman.

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Lake Coleman in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Lake Coleman was sampled one time as part of the 2007 NLA. The chlorophyll *a* concentration measured during sampling was 4.72 µg/L, indicating a low risk of exposure based on the chlorophyll *a* thresholds used in the NLA study. The microcystin concentration during sampling was below the reporting limit of 0.1 µg/L, indicating a low risk of exposure based on the microcystin thresholds used in the NLA study. The cyanobacteria cell count during sampling was less than 20,000 cells per milliliter, indicating a low risk of exposure based on the cyanobacteria thresholds used in the NLA study.

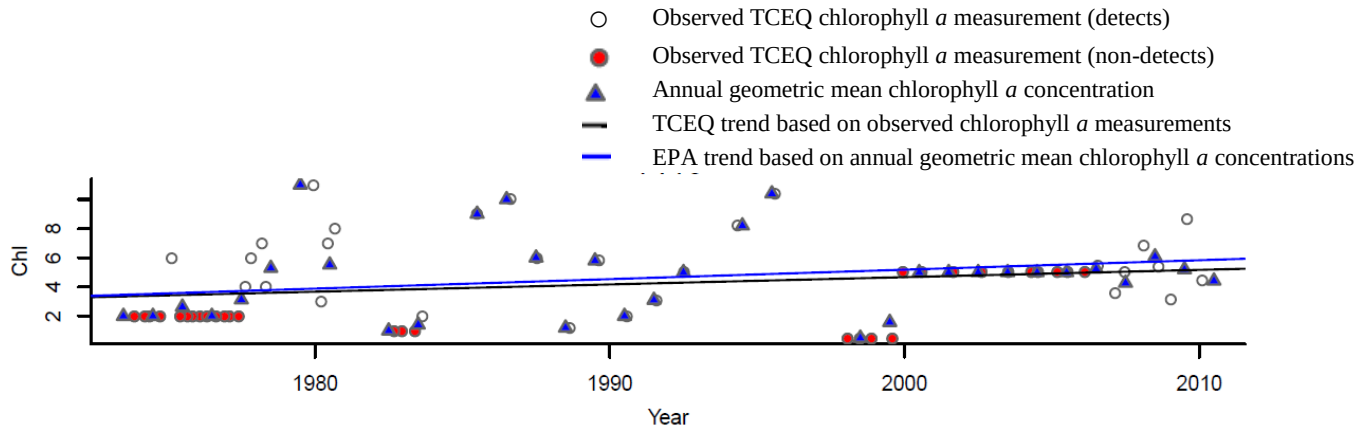
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ did not identify any statistically significant increasing trends in chlorophyll *a* concentrations for Lake Coleman (see Figure 27).

Figure 27. Chlorophyll *a* Trend for Lake Coleman Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Lake Coleman based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 28). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Lake Coleman, the magnitude of the slope of this increasing trend was relatively small at 0.065 µg/L chlorophyll *a*/year.

Figure 28. Chlorophyll *a* Trends for Lake Coleman Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Lake Coleman was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Lake Coleman between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 45.56 was determined for the 2010 reporting cycle for Lake Coleman. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 4.49 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Lake Coleman shifted from a mesotrophic classification for the 2000 reporting cycle to a eutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Lake Coleman, the chlorophyll *a* criterion is below 30 µg/L and 0% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Lake Coleman, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of Lake Coleman. Reservoir-specific data and information described above indicates a mesotrophic classification for Lake Coleman in the 2000 reporting cycle with a shift to a eutrophic classification in the 2010 reporting cycle, though EPA also noted that the Carlson's chlorophyll *a* TSI value of 45.56 determined for the 2010 reporting cycle is only 0.56 points above the mesotrophic-eutrophic classification boundary identified in TCEQ's trophic classification report (i.e., chlorophyll *a* TSI >45 is considered eutrophic). Reservoir-specific data and information described above indicates a relatively small rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.065 µg/L chlorophyll *a*/year) and an increasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. Additionally, TCEQ did not identify any CWA §303(d) listings for pH or DO for Lake Coleman, nor did it identify any concerns for nutrient or nutrient-enrichment related indicators. Further, 2007 NLA data indicated a low risk of exposure based on chlorophyll *a*, microcystin, and cyanobacteria thresholds, and none of the measurements in the underlying chlorophyll *a* dataset available for Lake Coleman were greater than 30

µg/L. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 6.07µg/L applicable to Lake Coleman is protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

15. <u>Lake Kickapoo, Segment 0213, Chlorophyll *a* Criterion 6.13 µg/L (Approved*)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 35 measurements collected between between August 22, 1973, and August 5, 2003. Of these 35 measurements, 2 were considered to be outliers because they had values greater than 11.7375 µg/L. So, the criterion was derived using a final dataset consisting of 33 chlorophyll *a* measurements collected between between August 22, 1973, and August 5, 2003, all of which were equal to or below 10.3 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Lake Kickapoo.

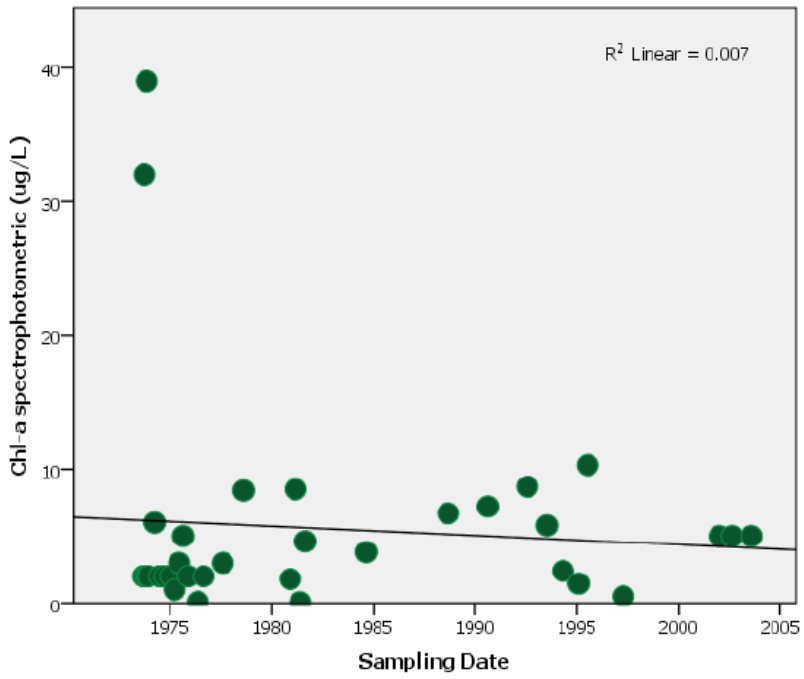
Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, no water quality concerns for any nutrient or nutrient enrichment-related indicators were identified for Lake Kickapoo.

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Lake Kickapoo in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Lake Kickapoo was not sampled as part of the 2007 NLA.

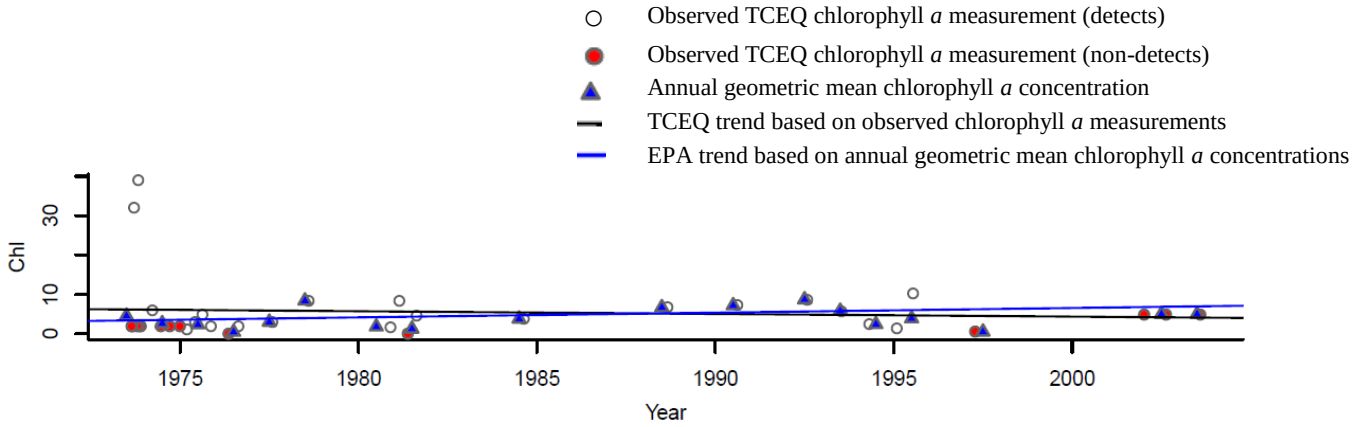
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ did not identify any statistically significant increasing trends in chlorophyll *a* concentrations for Lake Kickapoo (see Figure 29).

Figure 29. Chlorophyll *a* Trend for Lake Kickapoo Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Lake Kickapoo based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 30). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Lake Kickapoo, the magnitude of the slope of this increasing trend was relatively moderate at 0.119 µg/L chlorophyll *a*/year.

Figure 30. Chlorophyll *a* Trends for Lake Kickapoo Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Lake Kickapoo was not included in TCEQ's report titled *Trophic Classification of Texas Reservoirs*.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix

and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Lake Kickapoo, the chlorophyll *a* criterion is below 30 µg/L but 6% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Lake Kickapoo, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of Lake Kickapoo. While trophic state classification information was not available for Lake Kickapoo, reservoir-specific data and information described above indicates a relatively moderate rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.119 µg/L chlorophyll *a*/year) and a decreasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. Additionally, TCEQ did not identify any CWA §303(d) listings for pH or DO for Lake Kickapoo, nor did it identify any concerns for nutrient or nutrient-enrichment related indicators. Further, only 6% of the measurements in the underlying chlorophyll *a* dataset available for Lake Kickapoo were greater than 30 µg/L. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 6.13 µg/L applicable to Lake Kickapoo is protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

16. <u>Sam Rayburn Reservoir, Segment 0610, Chlorophyll *a* Criterion 6.22 µg/L (Approved)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 74 measurements collected between between August 21, 1996, and October 29, 2008. Of these 74 measurements, 5 were considered to be outliers because they had values greater than 10.63625 µg/L. So, the criterion was derived using a final dataset consisting of 69 chlorophyll *a* measurements collected between between August 21, 1996, and October 29, 2008, all of which were equal to or below 10.1 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for pH and DO listings in the 2000 through 2010 reporting cycles, the following 303(d) listings were identified for Sam Rayburn Reservoir:

Year	Parameter	Assessment Unit	Assessment Unit Description
2002	DO	n/a	Upper mid-Angelina River arm
2004	DO	n/a	Upper mid-Angelina River arm
2006	DO	0610_04	Upper mid-Angelina River arm
2000	DO	n/a	5,120 acres in the lower portion of Attoyac Bayou arm
2002	DO	n/a	Lower Attoyac Bayou arm
2004	DO	n/a	Lower Attoyac Bayou arm
2006	DO	0610_05	Lower Attoyac Bayou arm
2000	DO	n/a	3 acres at the extreme upper end of Angelina River arm upstream of Papermill Creek
2000	DO	n/a	5,120 acres at the upper end of the Angelina River arm downstream of Papermill Creek
2002	DO	n/a	Upper Angelina River arm
2004	DO	n/a	Upper Angelina River arm
2006	DO	0610_07	Upper Angelina River arm
2000	DO	n/a	5,120 acres in the upper portion of Ayish Bayou arm
2002	DO	n/a	Upper Ayish Bayou arm
2004	DO	n/a	Upper Ayish Bayou arm
2006	DO	0610_10	Upper Ayish Bayou arm

Year	Parameter	Assessment Unit	Assessment Unit Description
2000	DO	n/a	5,120 acres in the lower portion of the Agelina River arm midway between SH 103 and SH 147
2000	DO	n/a	5,120 acres in the middle portion of the Angelina River arm near SH 103
2000	low and high pH	n/a	area of SH 147

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Sam Rayburn Reservoir:

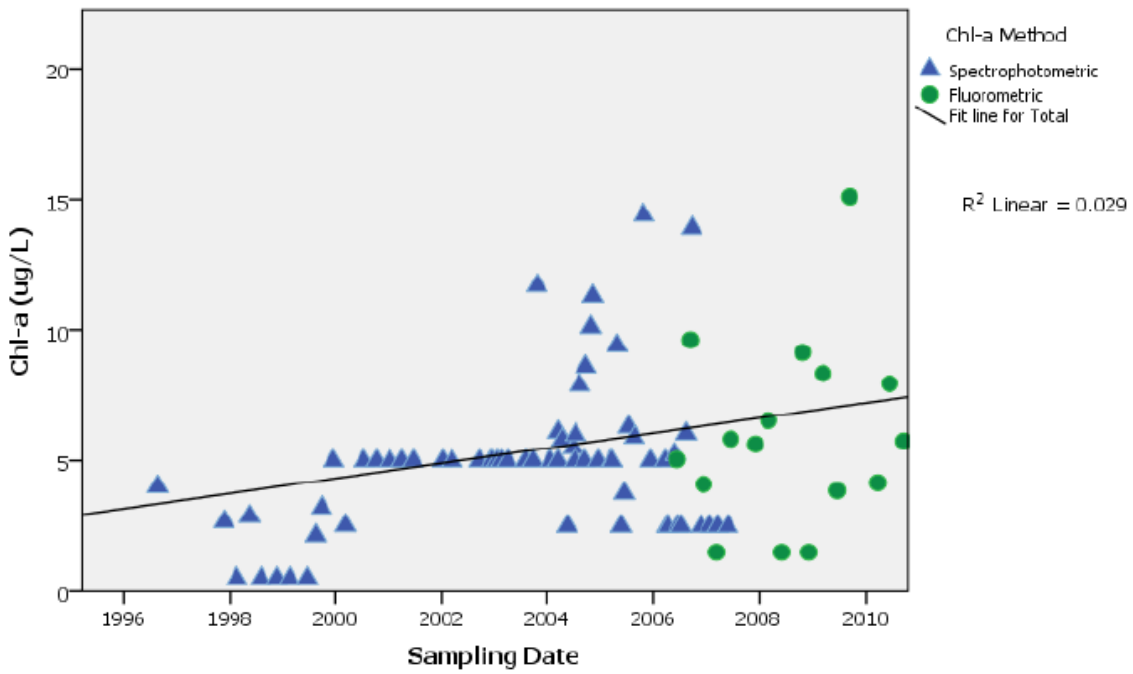
Year	Parameter	Assessment Unit	Assessment Unit Description
2006	NH3-N	0610_01	Main pool by the dam
2008	NH3-N	0610_01	Main pool by the dam
2010	NH3-N	0610_01	Sam Rayburn main pool by the dam to the Bear Creek and Ayish Arms
2006	NO3-N	0610_01	Main pool by the dam
2006	NH3-N	0610_02	Lower Angelina River arm
2008	NH3-N	0610_02	Lower Angelina River arm
2010	NH3-N	0610_02	Sam Rayburn lower Angelina River arm
2006	NO3-N	0610_02	Lower Angelina River arm
2006	NH3-N	0610_03	Mid-Angelina River arm (SH 147)
2008	NH3-N	0610_03	Mid-Angelina River arm (SH 147)
2010	NH3-N	0610_03	Sam Rayburn mid-Angelina River arm (area around SH 147)
2006	NO3-N	0610_03	Mid-Angelina River arm (SH 147)
2006	NH3-N	0610_04	Upper mid-Agelina River arm
2008	NH3-N	0610_04	Upper mid-Agelina River arm
2010	NH3-N	0610_04	Sam Rayburn upper mid-Agelina River arm
2006	NO3-N	0610_04	Upper mid-Agelina River arm
2008	NO3-N	0610_04	Upper mid-Agelina River arm
2010	NO3-N	0610_04	Sam Rayburn upper mid-Agelina River arm
2006	NH3-N	0610_05	Lower Attoyac Bayou arm
2008	NH3-N	0610_05	Lower Attoyac Bayou arm
2010	NH3-N	0610_05	Sam Rayburn lower Attoyac Bayou arm
2006	NO3-N	0610_05	Lower Attoyac Bayou arm
2008	NO3-N	0610_05	Lower Attoyac Bayou arm
2010	NO3-N	0610_05	Sam Rayburn lower Attoyac Bayou arm
2006	NH3-N	0610_08	Bear Creek arm
2008	NH3-N	0610_08	Bear Creek arm
2010	NH3-N	0610_08	Sam Rayburn Bear Creek arm
2006	NO3-N	0610_08	Bear Creek arm
2008	NO3-N	0610_08	Bear Creek arm
2006	NH3-N	0610_09	Lower Ayish Bayou arm
2008	NH3-N	0610_09	Lower Ayish Bayou arm
2010	NH3-N	0610_09	Sam Rayburn lower Ayish Bayou arm
2006	NO3-N	0610_09	Lower Ayish Bayou arm
2008	NO3-N	0610_09	Lower Ayish Bayou arm

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Sam Rayburn Reservoir in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Sam Rayburn Reservoir was sampled one time as part of the 2007 NLA. The chlorophyll *a* concentration measured during sampling was 9.6 µg/L, indicating a low risk of exposure based on the chlorophyll *a* thresholds used in the NLA study. The microcystin concentration during sampling was below the reporting limit of 0.1 µg/L, indicating a low risk of exposure based on the microcystin thresholds used in the NLA study. The cyanobacteria cell count during sampling was between 20,000 and 100,000 cells per milliliter, indicating a moderate risk of exposure based on the cyanobacteria thresholds used in the NLA study.

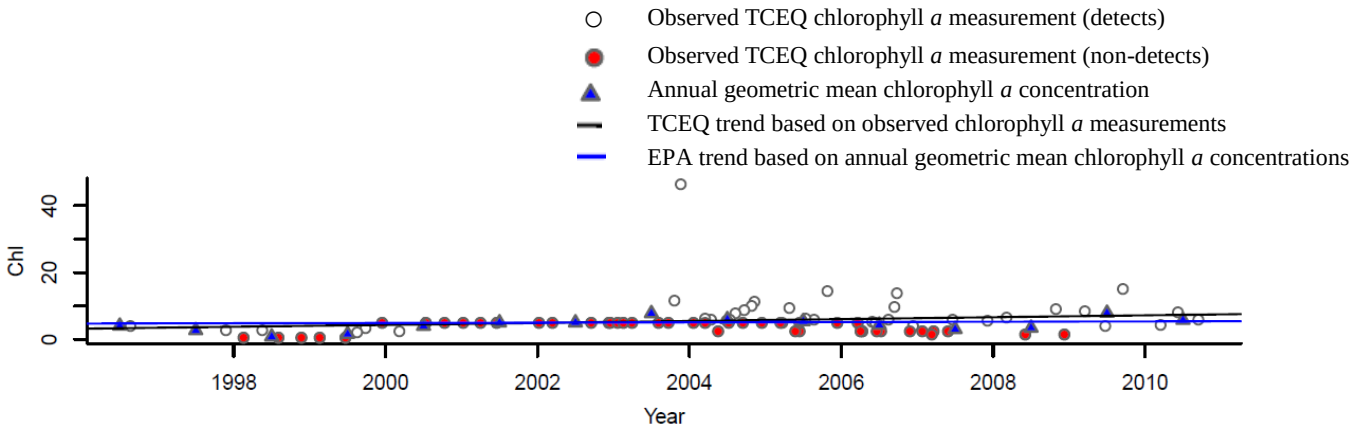
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ did not identify any statistically significant increasing trends in chlorophyll *a* concentrations for Sam Rayburn Reservoir (see Figure 31).

Figure 31. Chlorophyll *a* Trend for Sam Rayburn Reservoir Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Sam Rayburn Reservoir based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 32). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Sam Rayburn Reservoir, the magnitude of the slope of this increasing trend was relatively small at 0.046 µg/L chlorophyll *a*/year.

Figure 32. Chlorophyll *a* Trends for Sam Rayburn Reservoir Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Sam Rayburn Reservoir was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Sam Rayburn Reservoir between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 48.06 was determined for the 2010 reporting cycle for Sam Rayburn Reservoir. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 12.69 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Sam Rayburn Reservoir shifted from a mesotrophic classification for the 2000 reporting cycle to a eutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Sam Rayburn Reservoir, the chlorophyll *a* criterion is below 30 µg/L but 1% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Sam Rayburn Reservoir, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of Sam Rayburn Reservoir. Reservoir-specific data and information described above indicates a mesotrophic classification for Sam Rayburn Reservoir in the 2000 reporting cycle with a shift to a eutrophic classification in the 2010 reporting cycle. Reservoir-specific data and information described above indicates a relatively small rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.046 µg/L chlorophyll *a*/year) and an increasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. TCEQ did identify several CWA §303(d) listings for DO in Sam Rayburn Reservoir in the 2000 through 2006 reporting cycles, as well as one pH listing in the 2000 reporting cycle. However, all of the DO listings occurred in the riverine arms of the reservoir, and TCEQ has noted that criteria exceedances for for DO and pH tend to occur more often in the upper end and in cove areas of reservoirs in East Texas, and that in these cases the criteria for DO and pH tend to be very close to, and sometimes outside of, the range of natural conditions. TCEQ also identified several concerns for NH3-N and NO3-N in Sam Rayburn Reservoir in the 2006 through 2010 reporting cycles. 2007 NLA data for

Sam Rayburn Reservoir indicated a low risk of exposure based on chlorophyll *a* and microcystin thresholds, and a moderate risk of exposure based on cyanobacteria thresholds. Only 1% of the measurements in the underlying chlorophyll *a* dataset available for Sam Rayburn Reservoir were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is satisfied in the case of Sam Rayburn Reservoir, EPA strongly considered the relatively small rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.046 µg/L chlorophyll *a*/year) and the lack of statistically significant increasing trend in chlorophyll *a* concentration based on EPA's review of TCEQ's trend analysis, as well as the relatively low criterion magnitude (6.22 µg/L), and the fact that only 1% of the measurements in the underlying chlorophyll *a* dataset available for Sam Rayburn Reservoir were greater than 30 µg/L. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 6.22 µg/L applicable to Sam Rayburn Reservoir is protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

17. Belton Lake, Segment 1220, Chlorophyll *a* Criterion 6.38 µg/L (Approved*)

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 65 measurements collected between between July 9, 1990, and May 12, 2008. Of these 65 measurements, 1 was considered to be an outlier because it had a value greater than 12.525 µg/L. So, the criterion was derived using a final dataset consisting of 64 chlorophyll *a* measurements collected between between July 9, 1990, and May 12, 2008, all of which were equal to or below 12.01 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Belton Lake.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Belton Lake.

Year	Parameter	Assessment Unit	Assessment Unit Description
2010	Fish Kill	1220_01	Portion of Lake near Dam
2006	NO3-N	1220_01	Portion of Lake near Dam
2006	NO3-N	1220_02	Cowhouse Creek Arm
2010	Fish Kill	1220_03	Leon River Arm
2006	NO3-N	1220_03	Leon River Arm
2008	NO3-N	1220_03	Leon River Arm

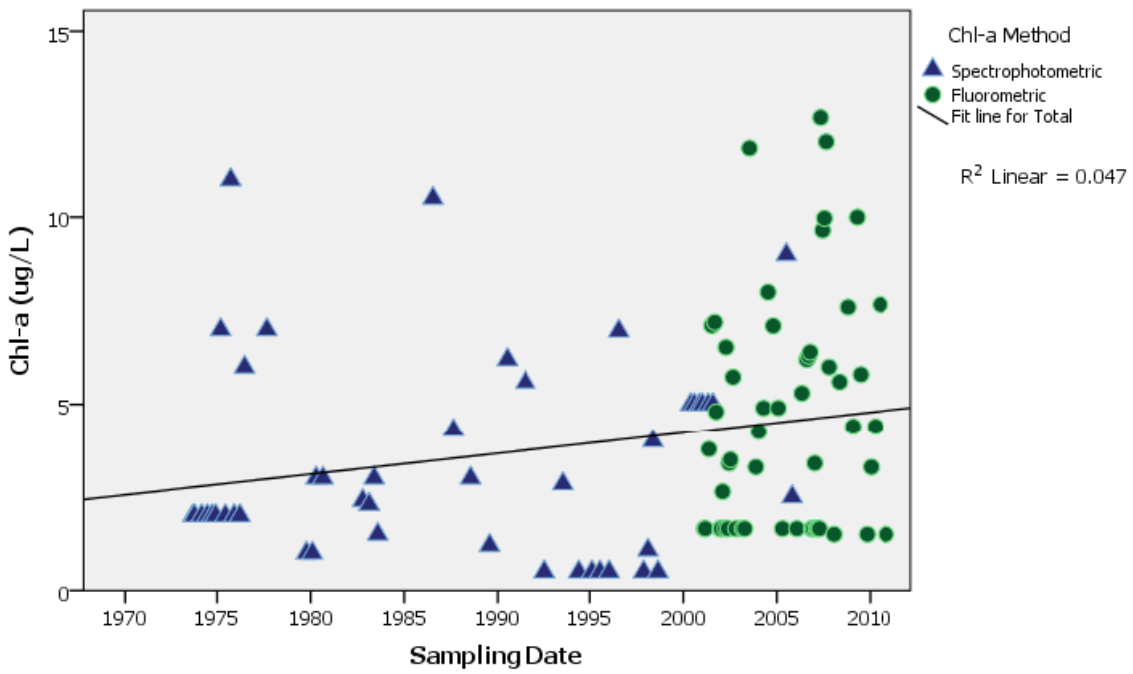
Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Belton Lake in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Belton Lake was not sampled as part of the 2007 NLA.

TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 99 chlorophyll *a* measurements collected from Belton Lake between 1973 and 2010 (see Figure 33). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created

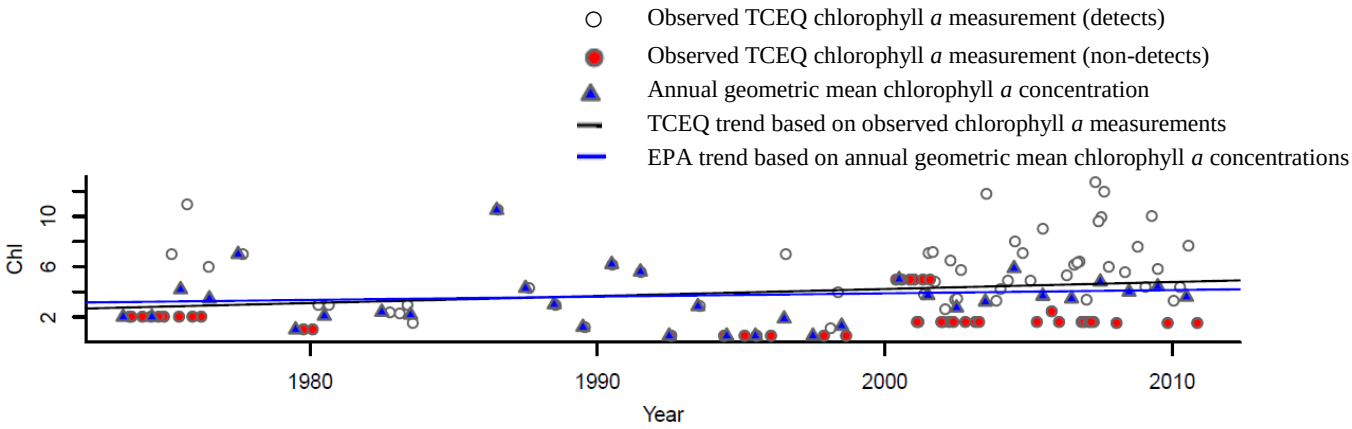
artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Belton Lake. Based upon the supporting information provided by TCEQ, a shift in methodology does appear to have occurred for this dataset in 2001 (most data after 2001 was collected using the fluorometric method rather than the spectrophotometric method). Forty-six chlorophyll *a* measurements were made using the spectrophotometric method, with 25 of these measurements (~54%) being reported as less than the minimum reporting limits. Fifty-three measurements were made using the fluorometric method, with 19 of these measurements (36%) being reported as less than the minimum reporting limits. When TCEQ analyzed trends for each of these datasets separately, neither the chlorophyll *a* data collected using the spectrophotometric method nor the chlorophyll *a* data collected using the fluorometric method showed a statistically significant increasing trend.

Figure 33. Chlorophyll *a* Trend for Belton Lake Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Belton Lake based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 34). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Belton Lake, the magnitude of the slope of this increasing trend was relatively small at 0.026 µg/L chlorophyll *a*/year.

Figure 34. Chlorophyll *a* Trends for Belton Lake Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Belton Lake was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Belton Lake between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 46.74 was determined for the 2010 reporting cycle for Belton Lake. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 10.62 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Belton Lake shifted from a mesotrophic classification for the 2000 reporting cycle to a eutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Belton Lake, the chlorophyll *a* criterion is below 30 µg/L and 0% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Belton Lake, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of Belton Lake. Reservoir-specific data and information described above indicates a mesotrophic classification for Belton Lake in the 2000 reporting cycle with a shift to a eutrophic classification in the 2010 reporting cycle, though EPA also noted that the Carlson's chlorophyll *a* TSI value of 46.74 determined for the 2010 reporting cycle is only 1.74 points above the mesotrophic-eutrophic classification boundary identified in TCEQ's trophic classification report (i.e., chlorophyll *a* TSI >45 is considered eutrophic). Reservoir-specific data and information described above indicates a relatively small rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.026 µg/L chlorophyll *a*/year) and an increasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. Additionally, TCEQ did not identify any CWA §303(d) listings for pH or DO for Belton Lake. While TCEQ did identify four concerns for nutrients (NO3-N) in Belton Lake in the 2006 and 2008 reporting cycles, these concerns were not repeating. TCEQ also identified two concerns for fish kills in the 2010 reporting cycle, but the cause of the fish kills, and whether or not they were related to nutrient overenrichment, is unclear.

Further, none of the measurements in the underlying chlorophyll *a* dataset available for Belton Lake were greater than 30 µg/L. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 6.38 µg/L applicable to Belton Lake is protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

18. <u>Oak Creek Reservoir, Segment 1426, Chlorophyll *a* Criterion 6.93 µg/L (Approved)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 43 measurements collected between between February 5, 1975, and January 7, 2009. Of these 43 measurements, 4 were considered to be outliers because they had values greater than 14.5 µg/L. So, the criterion was derived using a final dataset consisting of 39 chlorophyll *a* measurements collected between between February 5, 1975, and January 7, 2009, all of which were equal to or below 11.7 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Oak Creek Reservoir.

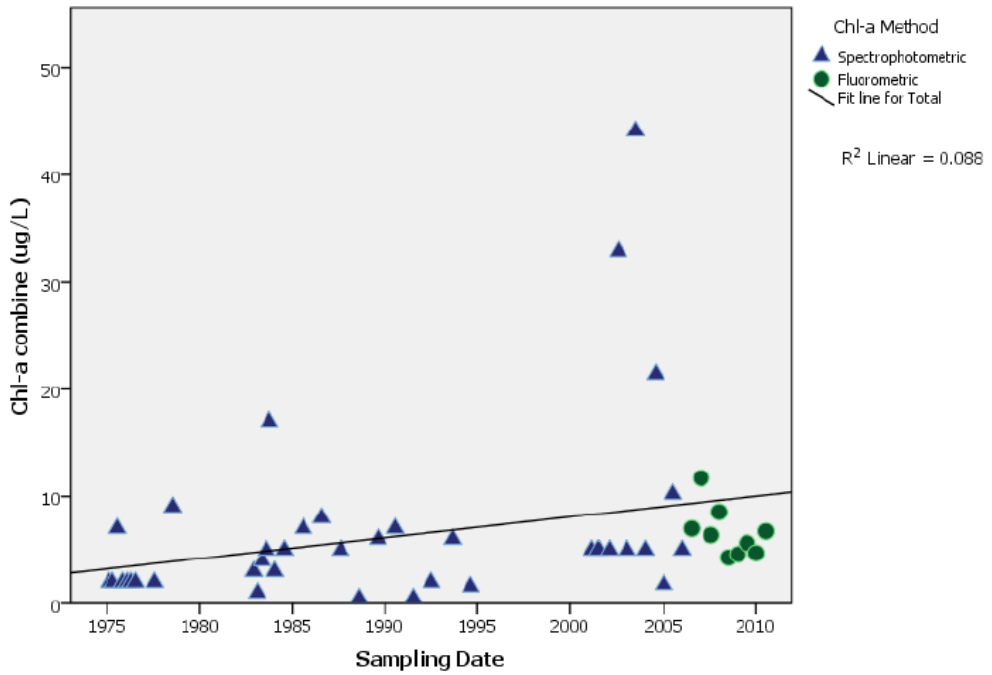
Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, no water quality concerns for any nutrient or nutrient enrichment-related indicators were identified for Oak Creek Reservoir.

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Oak Creek Reservoir in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Oak Creek Reservoir was not sampled as part of the 2007 NLA.

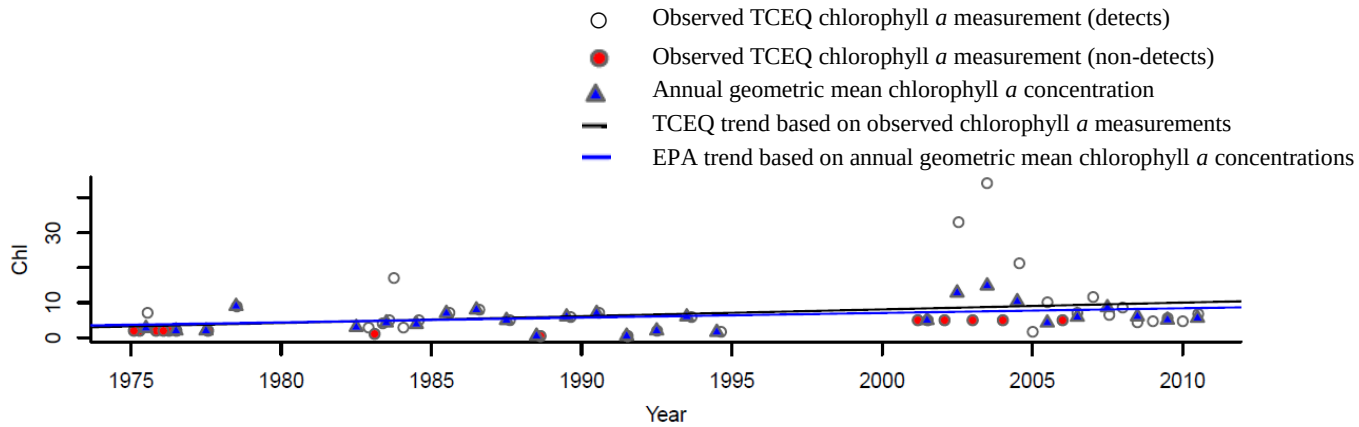
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 46 chlorophyll *a* measurements collected from Oak Creek Reservoir between 1975 and 2010 (see Figure 35). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Oak Creek Reservoir. Based upon the supporting information provided by TCEQ, a shift in methodology does appear to have occurred for this dataset in 2006 (all data after 2006 was collected using the fluorometric method rather than the spectrophotometric method). Thirty-seven chlorophyll *a* measurements were made using the spectrophotometric method, with 16 of these measurements (~43%) being reported as less than the minimum reporting limits. Nine measurements were made using the fluorometric method, with none of these measurements (0%) being reported as less than the minimum reporting limits. When TCEQ analyzed trends for each of these datasets separately, the chlorophyll *a* data collected using the fluorometic method did not show a statistically significant increasing trend, while the chlorophyll *a* data collected using the spectrophotometric method did show a statistically significant increasing trend. In further analyzing the spectrophotometric method dataset, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) affected the statistical significance of this chlorophyll *a* trend to such a degree that the increasing trend for Oak Creek Reservoir was no longer considered statistically significant.

Figure 35. Chlorophyll *a* Trend for Oak Creek Reservoir Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Oak Creek Reservoir based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 36). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Oak Creek Reservoir, the magnitude of the slope of this increasing trend was relatively moderate at 0.134 µg/L chlorophyll *a*/year.

Figure 36. Chlorophyll *a* Trends for Oak Creek Reservoir Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Oak Creek Reservoir was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Oak Creek Reservoir between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 55.58 was determined for the 2010 reporting cycle for Oak Creek

Reservoir. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 14.07 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Oak Creek Reservoir shifted from a mesotrophic classification for the 2000 reporting cycle to a hypereutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Oak Creek Reservoir, the chlorophyll *a* criterion is below 30 µg/L but 5% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Oak Creek Reservoir, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of Oak Creek Reservoir. Reservoir-specific data and information described above indicates a mesotrophic classification for Oak Creek Reservoir in the 2000 reporting cycle with a shift to a hypereutrophic classification in the 2010 reporting cycle. Reservoir-specific data and information described above indicates a relatively moderate rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.134 µg/L chlorophyll *a*/year) and an increasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. Additionally, TCEQ did not identify any CWA §303(d) listings for pH or DO for Oak Creek Reservoir, nor did it identify any concerns for nutrient or nutrient-enrichment related indicators. Further, only 5% of the measurements in the underlying chlorophyll *a* dataset available for Oak Creek Reservoir were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is satisfied in the case of Oak Creek Reservoir, EPA strongly considered the fact that the Carlson's chlorophyll *a* TSI value of 55.58 determined for the 2010 reporting cycle is only 0.58 points above the eutrophic-hypereutrophic classification boundary identified in TCEQ's trophic classification report (i.e., chlorophyll *a* TSI >55 is considered hypereutrophic), as well as the relatively moderate rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.134 µg/L chlorophyll *a*/year), and the lack of 303(d) listings and concerns noted above. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 6.93 µg/L applicable to Oak Creek Reservoir is protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

19. <u>Lake Crook, Segment 0208, Chlorophyll *a* Criterion 7.38 µg/L (Approved*)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 34 measurements collected between between October 25, 1973, and August 22, 1994. Of these 34 measurements, 1 was considered to be an outlier because it had a value greater than 14.5 µg/L. So, the criterion was derived using a final dataset consisting of 33 chlorophyll *a* measurements collected between between October 25, 1973, and August 22, 1994, all of which were equal to or below 13 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Lake Crook.

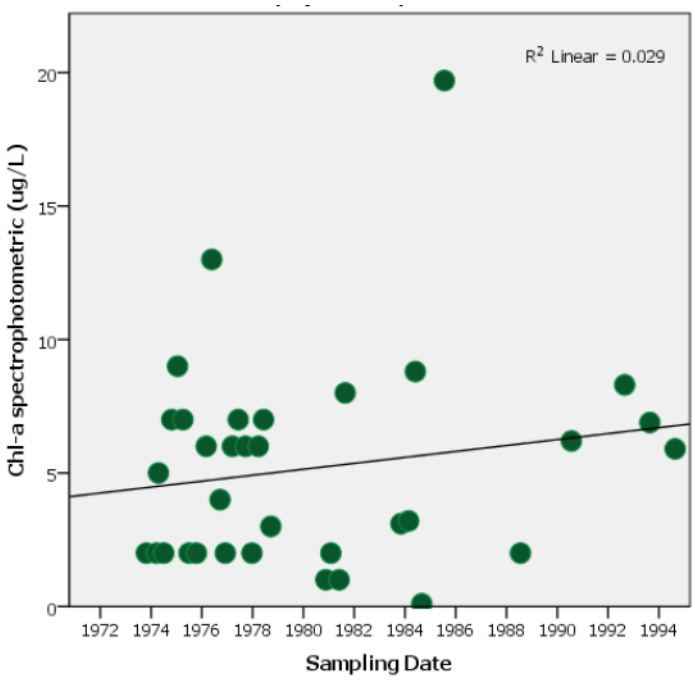
Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, no water quality concerns for any nutrient or nutrient enrichment-related indicators were identified for Lake Crook.

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Lake Crook in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Lake Crook was not sampled as part of the 2007 NLA.

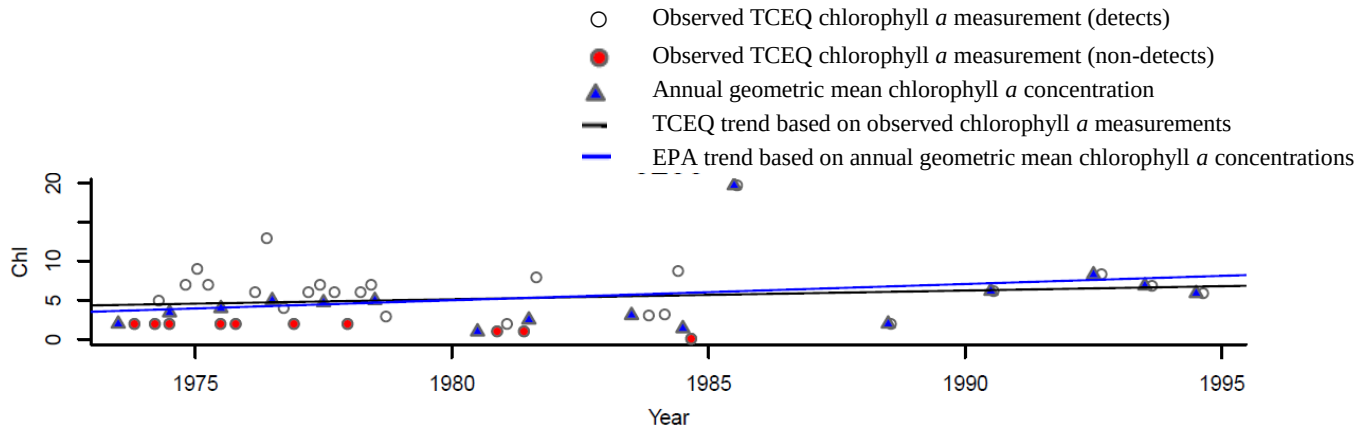
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ did not identify any statistically significant increasing trends in chlorophyll *a* concentrations for Lake Crook (see Figure 37).

Figure 37. Chlorophyll *a* Trend for Lake Crook Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Lake Crook based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 38). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Lake Crook, the magnitude of the slope of this increasing trend was relatively high at 0.208 µg/L chlorophyll *a*/year.

Figure 38. Chlorophyll *a* Trends for Lake Crook Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Lake Crook was not included in TCEQ's report titled *Trophic Classification of Texas Reservoirs*.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Lake Crook, the chlorophyll *a* criterion is below 30 µg/L and 0% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Lake Crook, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of Lake Crook. Trophic state classification information was not available for Lake Crook. Reservoir-specific data and information described above indicates a relatively high rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.208 µg/L chlorophyll *a*/year) and an increasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. However, TCEQ did not identify any CWA §303(d) listings for pH or DO for Lake Crook, nor did it identify any concerns for nutrient or nutrient-enrichment related indicators. Further, none of the measurements in the underlying chlorophyll *a* dataset available for Lake Crook were greater than 30 µg/L. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 7.38 µg/L applicable to Lake Crook is protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

20. <u>Lady Bird Lake (Town Lake), Segment 1429, Chlorophyll *a* Criterion 7.56 µg/L (Approved*)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 163 measurements collected between between January 30, 1990, and August August 25, 2008. Of these 163 measurements, 12 were considered to be outliers because they had values greater than 16.945 µg/L. So, the criterion was derived using a final dataset consisting of 151 chlorophyll *a* measurements collected between between January 30, 1990, and August 25, 2008, all of which were equal to or below 15.8 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Lady Bird Lake.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Lady Bird Lake:

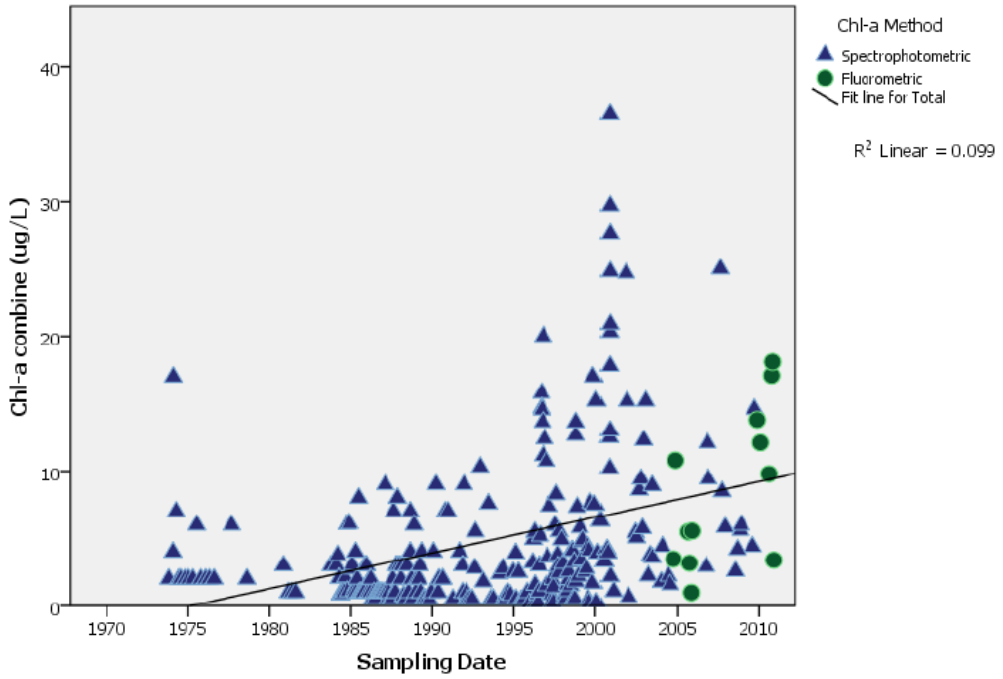
Year	Parameter	Assessment Unit	Assessment Unit Description
2006	NO3-N	1429_01	Longhorn Dam upstream to Lamar Street bridge
2008	NO3-N	1429_01	Longhorn Dam upstream to Lamar Street bridge
2010	NO3-N	1429_01	Longhorn Dam upstream to Lamar Street bridge

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Lady Bird Lake in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Lady Bird Lake was not sampled as part of the 2007 NLA.

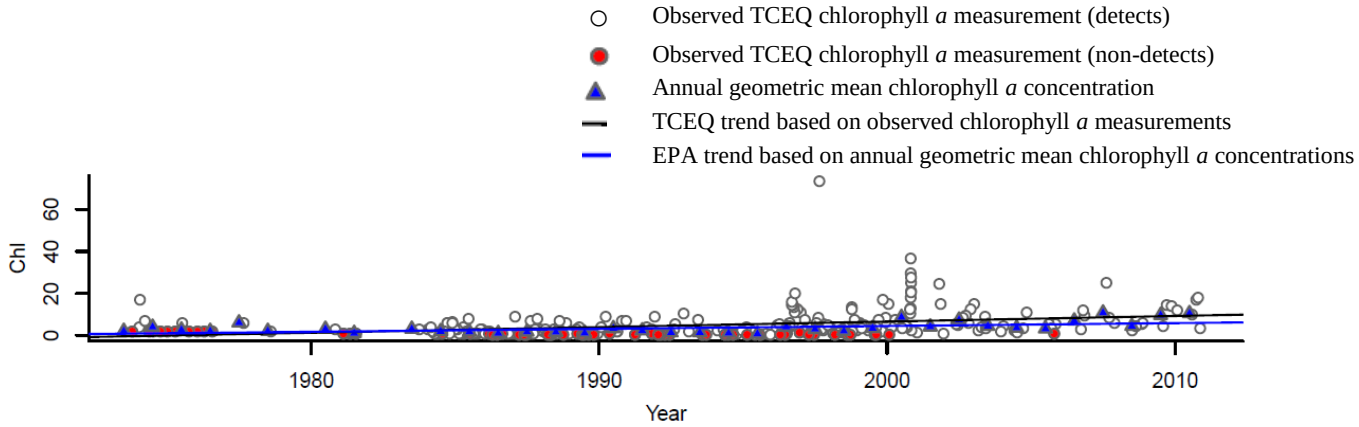
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 268 chlorophyll *a* measurements collected from Lady Bird Lake between 1973 and 2010 (see Figure 39). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Lady Bird Lake. Based upon the supporting information provided by TCEQ, a shift in methodology does appear to have occurred for this dataset in 2004 (with some data after 2004 being collected using the fluorometric method rather than the spectrophotometric method). Two hundred and fifty-six chlorophyll *a* measurements were made using the spectrophotometric method, with 56 of these measurements (~22%) being reported as less than the minimum reporting limits. Twelve measurements were made using the fluorometric method, with 1 of these measurements (~8%) being reported as less than the minimum reporting limits. When TCEQ analyzed trends for each of these datasets separately, the chlorophyll *a* data collected using the spectrophotometric method did show a statistically significant increasing trend, as did chlorophyll *a* data collected using the fluorometric method. For each of these datasets, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) did not affect the statistical significance of these chlorophyll *a* trends to such a degree that the trends became statistically insignificant. Therefore, EPA believes that these increasing trends for Lady Bird Lake are statistically significant.

Figure 39. Chlorophyll *a* Trend for Lady Bird Lake Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Lady Bird Lake based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 40). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Lady Bird Lake, the magnitude of the slope of this increasing trend was relatively moderate at 0.138 µg/L chlorophyll *a*/year.

Figure 40. Chlorophyll *a* Trends for Lady Bird Lake Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Lady Bird Lake was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Lady Bird Lake between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 49.58 was determined for the 2010 reporting cycle for Lady Bird Lake. This value

was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 13.22 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Lady Bird Lake shifted from a mesotrophic classification for the 2000 reporting cycle to a eutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Lady Bird Lake, the chlorophyll *a* criterion is below 30 µg/L but 1% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Lady Bird Lake, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of Lady Bird Lake. Reservoir-specific data and information described above indicates a mesotrophic classification for Lady Bird Lake in the 2000 reporting cycle with a shift to a eutrophic classification in the 2010 reporting cycle. Reservoir-specific data and information described above indicates a relatively moderate rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.138 µg/L chlorophyll *a*/year) and a statisticially significant increasing trend in chlorophyll *a* concentration based on EPA's review of TCEQ's trend analysis. TCEQ did not identify any CWA §303(d) listings for pH or DO for Lady Bird Lake. TCEQ identified three nutrient (NO3-N) concerns for the same assessment unit in Lady Bird Lake in the 2006 through 2010 reporting cycles. Only 1% of the measurements in the underlying chlorophyll *a* dataset available for Lady Bird Lake were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is satisfied in the case of Lady Bird Lake, EPA strongly considered the relatively moderate rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.138 µg/L chlorophyll *a*/year), the relatively low criterion magnitude (7.56 ug/L), and the fact that only 1% of the measurements in the underlying chlorophyll *a* dataset available for Lady Bird Lake were greater than 30 µg/L. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 7.56 µg/L applicable to Lady Bird Lake is protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

21. <u>Lake Cherokee, Segment 0510, Chlorophyll *a* Criterion 8.25 µg/L (Approved*)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 33 measurements collected between between October 12, 1973, and June 2, 1994. Of these 33 measurements, 2 were considered to be outliers because they had values greater than 16.65 µg/L. So, the criterion was derived using a final dataset consisting of 31 chlorophyll *a* measurements collected between between October 12, 1973, and June 2, 1994, all of which were equal to or below 11 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Lake Cherokee.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles,

the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Lake Cherokee:

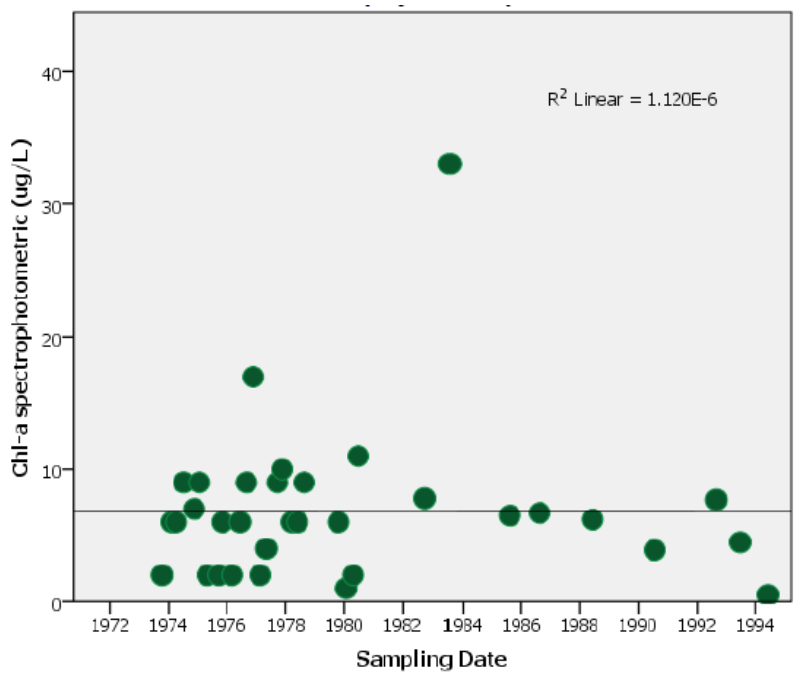
Year	Parameter	Assessment Unit	Assessment Unit Description
2008	OP	0510_01	Lower 2352 acres of reservoir
2006	DO	0510_02	Upper 1629 acres of reservoir
2008	DO	0510_02	Upper 1629 acres of reservoir
2010	DO	0510_02	Upper 1629 acres of reservoir
2008	OP	0510_02	Upper 1629 acres of reservoir
2010	pH	0510_02	Upper 1629 acres of reservoir

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Lake Cherokee in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Lake Cherokee was not sampled as part of the 2007 NLA.

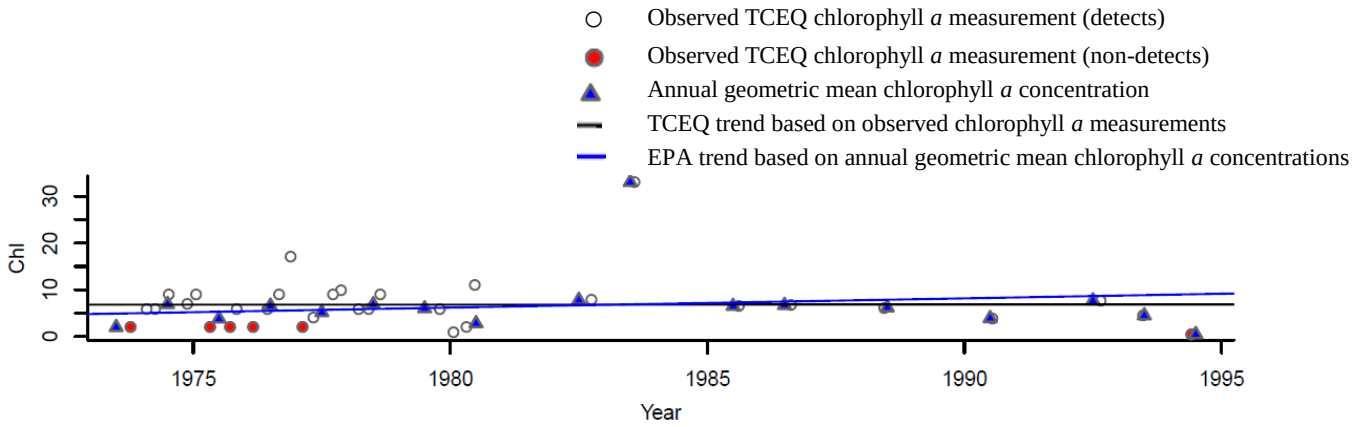
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ did not identify any statistically significant increasing trends in chlorophyll *a* concentrations for Lake Cherokee (see Figure 41).

Figure 41. Chlorophyll *a* Trend for Lake Cherokee Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Lake Cherokee based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 42). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Lake Cherokee, the magnitude of the slope of this increasing trend was relatively moderate at 0.197 µg/L chlorophyll *a*/year.

Figure 42. Chlorophyll *a* Trends for Lake Cherokee Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Lake Cherokee was not included in TCEQ's report titled *Trophic Classification of Texas Reservoirs*.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Lake Cherokee, the chlorophyll *a* criterion is below 30 µg/L but 3% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Lake Cherokee, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of Lake Cherokee. Trophic state classification information was not available for Lake Cherokee. Reservoir-specific data and information described above indicates a relatively moderate rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.197 µg/L chlorophyll *a*/year) and an increasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. TCEQ did not identify any CWA §303(d) listings for pH or DO for Lake Cherokee. While TCEQ did identify two concerns for nutrients (OP) in Lake Cherokee in the 2008 reporting cycle, these concerns were not repeating. TCEQ also identified three concerns for DO and one concern for pH in the assessment unit encompassing the upper portion of the reservoir in the 2006 through 2010 reporting cycles. Only 3% of the measurements in the underlying chlorophyll *a* dataset available for Lake Cherokee were greater than 30 µg/L. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 8.25 µg/L applicable to Lake Cherokee is protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

22. <u>Lake Kemp, Segment 0217, Chlorophyll *a* Criterion 8.83 µg/L (Approved*)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 61 measurements collected between between September 5, 1973, and June 10, 2008. Of these 61 measurements, 2 were considered to be outliers because they had values greater than 15.5 µg/L. So, the criterion was derived using a final dataset consisting of 59 chlorophyll *a* measurements collected between between September 5, 1973, and June 10, 2008, all of which were equal to or below 15 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Lake Kemp.

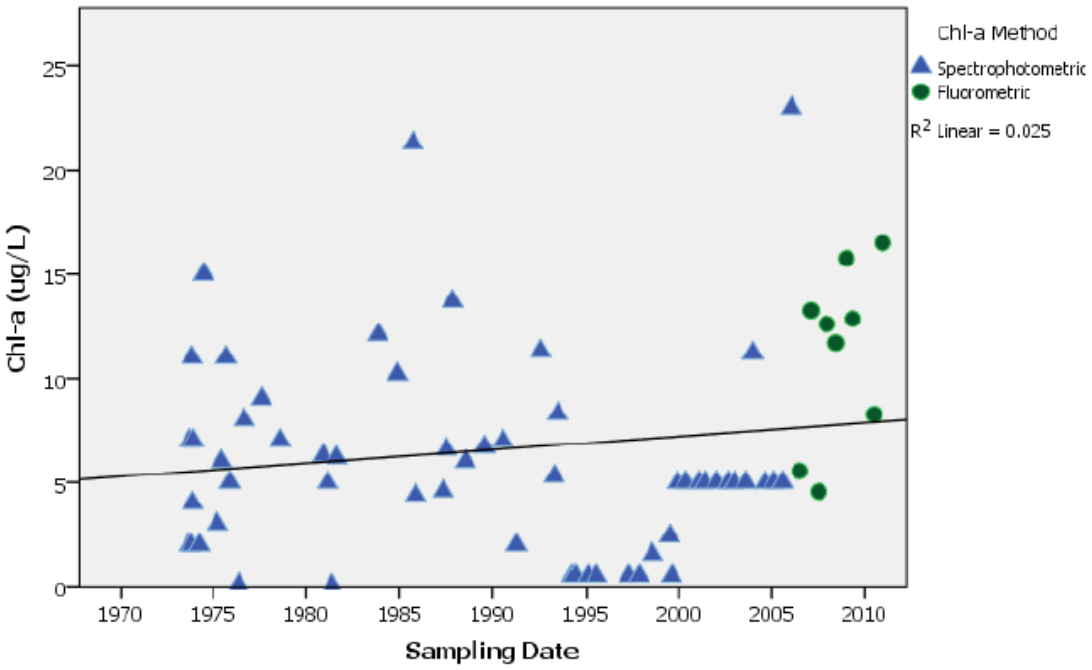
Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, no water quality concerns for any nutrient or nutrient enrichment-related indicators were identified for Lake Kemp.

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Lake Kemp in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Lake Kemp was sampled one time as part of the 2007 NLA. The chlorophyll *a* concentration measured during sampling was 6 µg/L, indicating a low risk of exposure based on the chlorophyll *a* thresholds used in the NLA study. The microcystin concentration during sampling was below the reporting limit of 0.1 µg/L, indicating a low risk of exposure based on the microcystin thresholds used in the NLA study. The cyanobacteria cell count during sampling was less than 20,000 cells per milliliter, indicating a low risk of exposure based on the cyanobacteria thresholds used in the NLA study.

TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ did not identify any statistically significant increasing trends in chlorophyll *a* concentrations for Lake Kemp (see Figure 43).

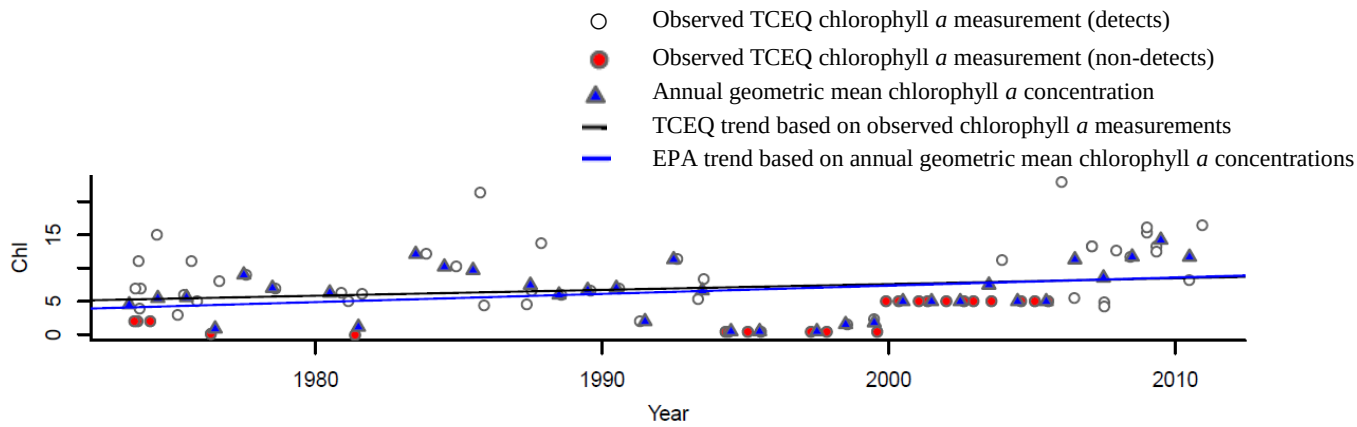
Figure 43. Chlorophyll *a* Trend for Lake Kemp Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Lake Kemp based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure

44). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Lake Kemp, the magnitude of the slope of this increasing trend was relatively moderate at 0.123 µg/L chlorophyll *a*/year.

Figure 44. Chlorophyll *a* Trends for Lake Kemp Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Lake Kemp was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Lake Kemp between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 49.96 was determined for the 2010 reporting cycle for Lake Kemp. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 10.94 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Lake Kemp shifted from a mesotrophic classification for the 2000 reporting cycle to a eutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Lake Kemp, the chlorophyll *a* criterion is below 30 µg/L and 0% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Lake Kemp, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of Lake Kemp. Reservoir-specific data and information described above indicates a mesotrophic classification for Lake Kemp in the 2000 reporting cycle with a shift to a eutrophic classification in the 2010 reporting cycle. Reservoir-specific data and information described above indicates a relatively moderate rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.123 µg/L chlorophyll *a*/year) and an increasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. TCEQ did not identify any CWA §303(d) listings for pH or DO for Lake Kemp, nor did it identify any concerns for nutrient or nutrient-enrichment related indicators. Further, 2007 NLA data indicated a low risk of exposure based on chlorophyll *a*, microcystin, and cyanobacteria thresholds, and none of the

measurements in the underlying chlorophyll *a* dataset available for Lake Kemp were greater than 30 µg/L. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 8.83 µg/L applicable to Lake Kemp is protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

23. <u>Lake Buchanan, Segment 1408, Chlorophyll *a* Criterion 9.82 µg/L (Approved*)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 109 measurements collected between between February 1, 1990, and December 4, 2008. Of these 109 measurements, 4 were considered to be outliers because they had values greater than 19.555 µg/L. So, the criterion was derived using a final dataset consisting of 105 chlorophyll *a* measurements collected between between February 1, 1990, and December 4, 2008, all of which were equal to or below 18.1 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Lake Buchanan.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Lake Buchanan:

Year	Parameter	Assessment Unit	Assessment Unit Description
2006	Chl-a	1408_05	From the Willow Slough area upstream to the headwaters near the Yancey Creek confluence
2008	Chl-a	1408_05	From the Willow Slough area upstream to the headwaters near the Yancey Creek confluence
2010	Chl-a	1408_05	From the Willow Slough area upstream to the headwaters near the Yancey Creek confluence

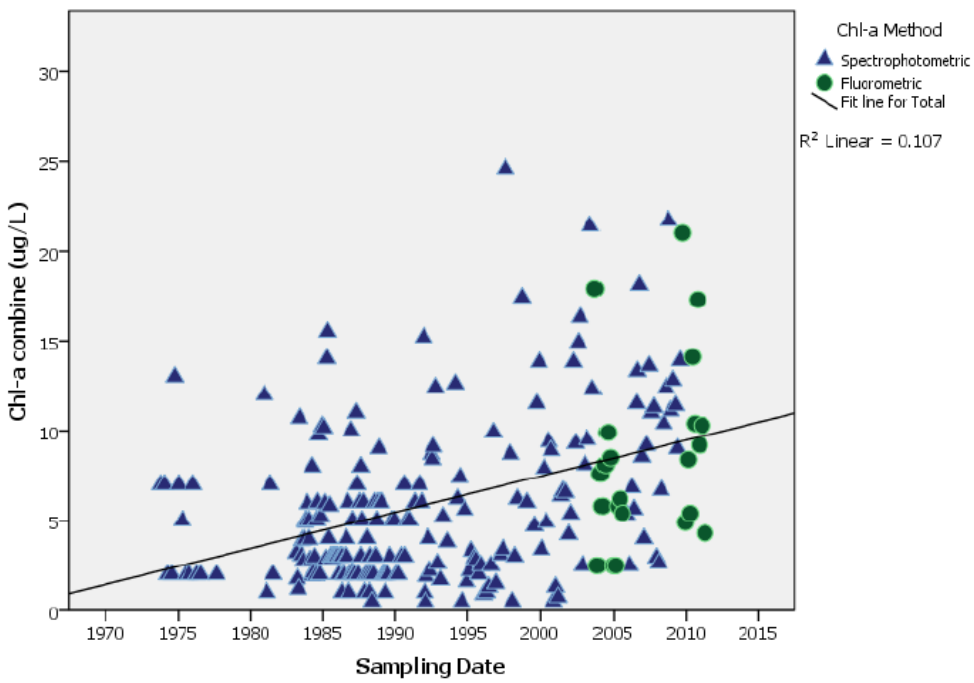
Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Lake Buchanan in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Lake Buchanan was not sampled as part of the 2007 NLA.

TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 232 chlorophyll *a* measurements collected from Lake Buchanan between 1973 and 2011 (see Figure 45). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Lake Buchanan. Based upon the supporting information provided by TCEQ, a shift in methodology does appear to have occurred for this dataset in 2003 (with some data after 2003 being collected using the fluorometric method rather than the spectrophotometric method). Two hundred and ten chlorophyll *a* measurements were made using the spectrophotometric method, with 14 of these measurements (~7%) being reported as less than the minimum reporting limits. Twenty-two measurements were made using the fluorometric method, with 3 of these measurements (~14%) being reported as less than the minimum reporting limits. When TCEQ analyzed trends for each of these datasets separately, the chlorophyll *a* data collected using the fluorometic method did not show a

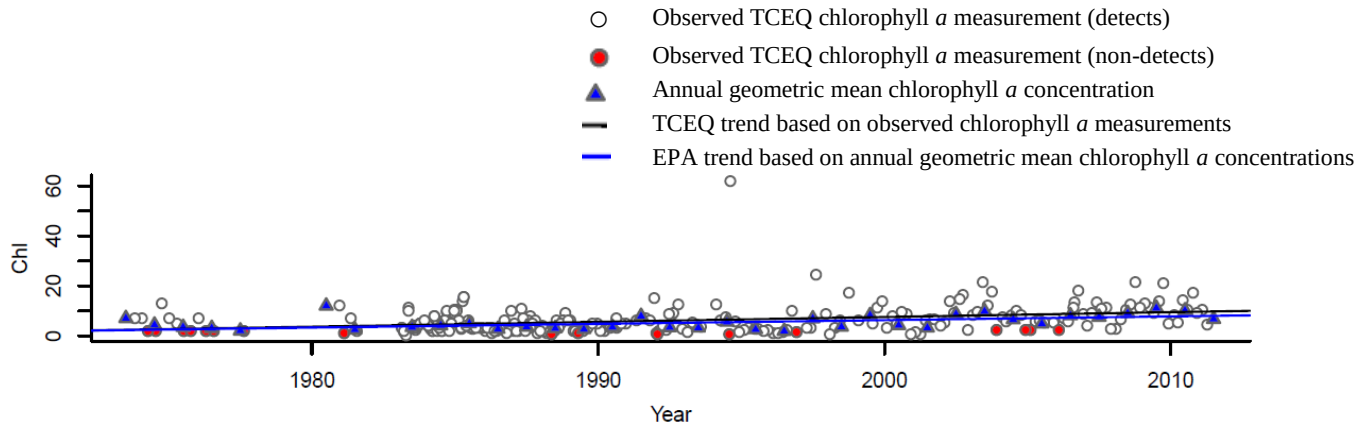
statistically significant increasing trend, while the chlorophyll *a* data collected using the spectrophotometric method did show a statistically significant increasing trend. In further analyzing the spectrophotometric method dataset, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) did not affect the statistical significance of this chlorophyll *a* trend to such a degree that the trend became statistically insignificant. Therefore, EPA believes that this increasing trend for Lake Buchanan is statistically significant.

Figure 45. Chlorophyll *a* Trend for Lake Buchanan Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Lake Buchanan based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 46). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Lake Buchanan, the magnitude of the slope of this increasing trend was relatively moderate at 0.151 µg/L chlorophyll *a*/year.

Figure 46. Chlorophyll *a* Trends for Lake Buchanan Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Lake Buchanan was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Lake Buchanan between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 51.60 was determined for the 2010 reporting cycle for Lake Buchanan. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 9.03 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Lake Buchanan shifted from a mesotrophic classification for the 2000 reporting cycle to a eutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Lake Buchanan, the chlorophyll *a* criterion is below 30 µg/L and 0% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Lake Buchanan, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of Lake Buchanan. Reservoir-specific data and information described above indicates a mesotrophic classification for Lake Buchanan in the 2000 reporting cycle with a shift to a eutrophic classification in the 2010 reporting cycle. Reservoir-specific data and information described above indicates a relatively moderate rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.151 µg/L chlorophyll *a*/year) and a statisticially significant increasing trend in chlorophyll *a* concentration based on EPA's review of TCEQ's trend analysis. TCEQ did not identify any CWA §303(d) listings for pH or DO for Lake Buchanan. While TCEQ did identify three concerns for chlorophyll *a* in Lake Buchanan during the 2006 through 2010 reporting cycles, these concerns were not associated with the assessment unit encompassing the main pool near the dam, and TCEQ did not identify concerns for any other nutrient-enrichment related indicators or any nutrient indicators. Further, none of the measurements in the underlying chlorophyll *a* dataset available for Lake Buchanan were greater than 30 µg/L. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 9.82 µg/L applicable to Lake Buchanan is protective of the reservoir's

designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

24. <u>Lake Lyndon B. Johnson, Segment 1406, Chlorophyll *a* Criterion 10.29 µg/L (Approved*)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 105 measurements collected between between January 18, 1990, and December 8, 2008. Of these 105 measurements, 4 were considered to be outliers because they had values greater than 19.25 µg/L. So, the criterion was derived using a final dataset consisting of 101 chlorophyll *a* measurements collected between between January 18, 1990, and December 8, 2008, all of which were equal to or below 19.1 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Lake Lyndon B. Johnson.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Lake Lyndon B. Johnson:

Year	Parameter	Assessment Unit	Assessment Unit Description
2006	DO	1406_01	From Alvin Wirtz Dam upstream to Granite Shoals
2008	DO	1406_01	From Alvin Wirtz Dam upstream to Granite Shoals
2010	DO	1406_01	From Alvin Wirtz Dam upstream to the Pecan Creek Arm
2006	DO	1406_06	From a point near Pair Lane in Kingsland upstream to Roy Inks Dam
2008	DO	1406_06	From a point near Pair Lane in Kingsland upstream to Roy Inks Dam
2010	DO	1406_06	From the Williams Creek confluence upstream to Roy Inks Dam

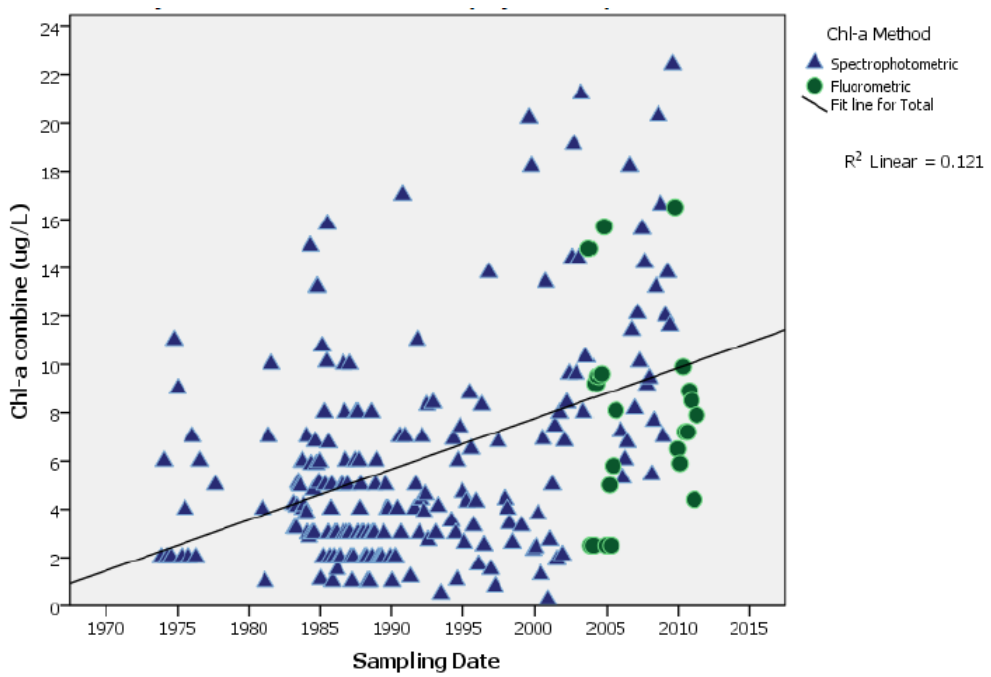
Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Lake Lyndon B. Johnson in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Lake Lyndon B. Johnson was not sampled as part of the 2007 NLA.

TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 229 chlorophyll *a* measurements collected from Lake Lyndon B. Johnson between 1973 and 2011 (see Figure 47). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Lake Lyndon B. Johnson. Based upon the supporting information provided by TCEQ, a shift in methodology does appear to have occurred for this dataset in 2003 (with some data after 2003 being collected using the fluorometric method rather than the spectrophotometric method). Two hundred and seven chlorophyll *a* measurements were made using the spectrophotometric method, with 11 of these measurements (~5%) being reported as less than the minimum reporting limits. Twenty-two measurements were made using the fluorometric method, with 4 of these measurements (~18%) being reported as less than the minimum reporting limits. When TCEQ analyzed trends for each of these datasets separately, the chlorophyll *a* data collected using the fluorometic method did not show a statistically significant increasing trend, while the chlorophyll *a* data

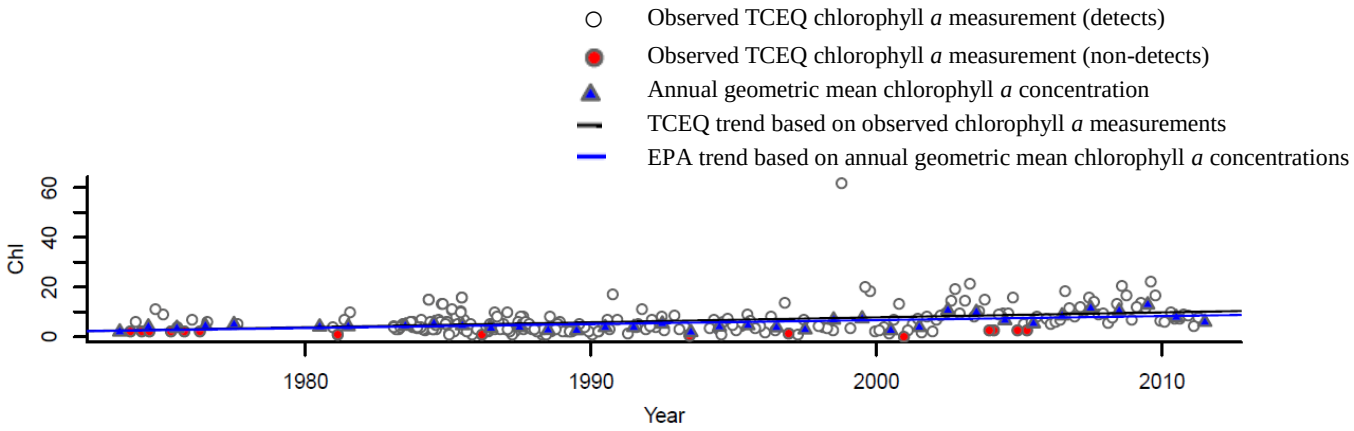
collected using the spectrophotometric method did show a statistically significant increasing trend. In further analyzing the spectrophotometric method dataset, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) did not affect the statistical significance of this chlorophyll *a* trend to such a degree that the trend became statistically insignificant. Therefore, EPA believes that this increasing trend for Lake Lyndon B. Johnson is statistically significant.

Figure 47. Chlorophyll *a* Trend for Lake Lyndon B. Johnson Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Lake Lyndon B. Johnson based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 48). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Lake Lyndon B. Johnson, the magnitude of the slope of this increasing trend was relatively moderate at 0.161 µg/L chlorophyll *a*/year.

Figure 48. Chlorophyll *a* Trends for Lake Lyndon B. Johnson Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Lake Lyndon B. Johnson was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Lake Lyndon B. Johnson between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 52.68 was determined for the 2010 reporting cycle for Lake Lyndon B. Johnson. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 13.87 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Lake Lyndon B. Johnson shifted from a mesotrophic classification for the 2000 reporting cycle to a eutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Lake Lyndon B. Johnson, the chlorophyll *a* criterion is below 30 µg/L and 0% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Lake Lyndon B. Johnson, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of Lake Lyndon B. Johnson. Reservoir-specific data and information described above indicates a mesotrophic classification for Lake Lyndon B. Johnson in the 2000 reporting cycle with a shift to a eutrophic classification in the 2010 reporting cycle. Reservoir-specific data and information described above indicates a relatively moderate rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.161 µg/L chlorophyll *a*/year) and a statisticially significant increasing trend in chlorophyll *a* concentration based on EPA's review of TCEQ's trend analysis. TCEQ did not identify any CWA §303(d) listings for pH or DO for Lake Lyndon B. Johnson. While TCEQ did identify six concerns for DO in Lake Lyndon B. Johnson during the 2006 through 2010 reporting cycles, TCEQ did not identify concerns for any other nutrient-enrichment related indicators or any nutrient indicators. Further, none of the measurements in the underlying chlorophyll *a* dataset available for Lake Lyndon B. Johnson were greater than 30 µg/L. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 10.29 µg/L applicable to Lake Lyndon B. Johnson is

protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

25. <u>Marble Falls Lake, Segment 1405, Chlorophyll *a* Criterion 10.48 µg/L (Approved*)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 109 measurements collected between between February 2, 1990, and December 1, 2008. Of these 109 measurements, 4 were considered to be outliers because they had values greater than 20.2 µg/L. So, the criterion was derived using a final dataset consisting of 105 chlorophyll *a* measurements collected between between February 2, 1990, and December 1, 2008, all of which were equal to or below 19.2 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Marble Falls Lake.

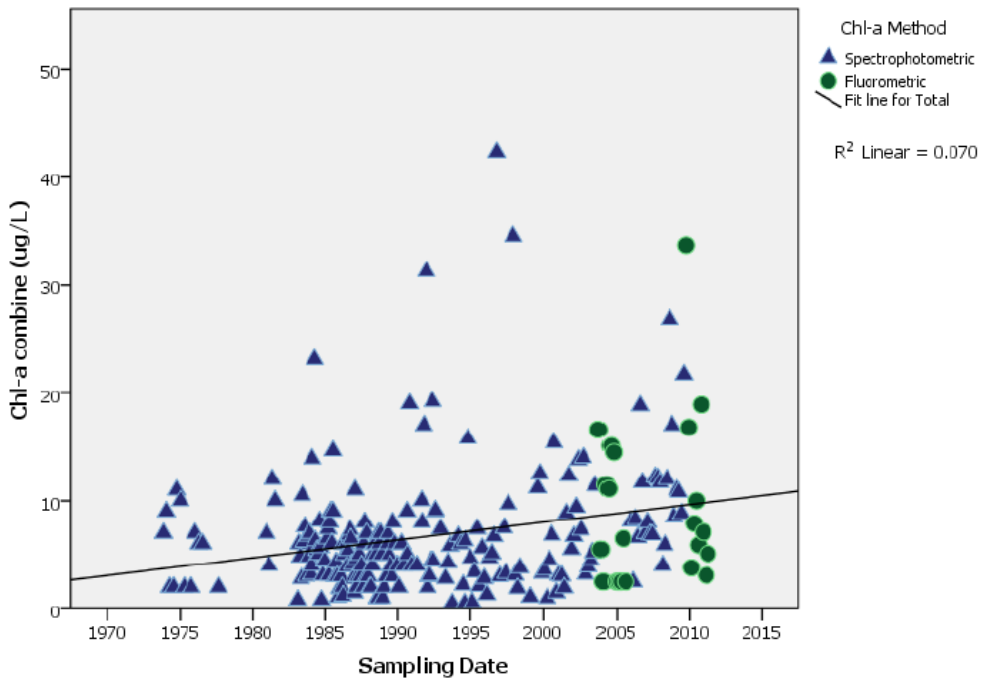
Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, no water quality concerns for any nutrient or nutrient enrichment-related indicators were identified for Marble Falls Lake.

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Marble Falls Lake in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Marble Falls Lake was not sampled as part of the 2007 NLA.

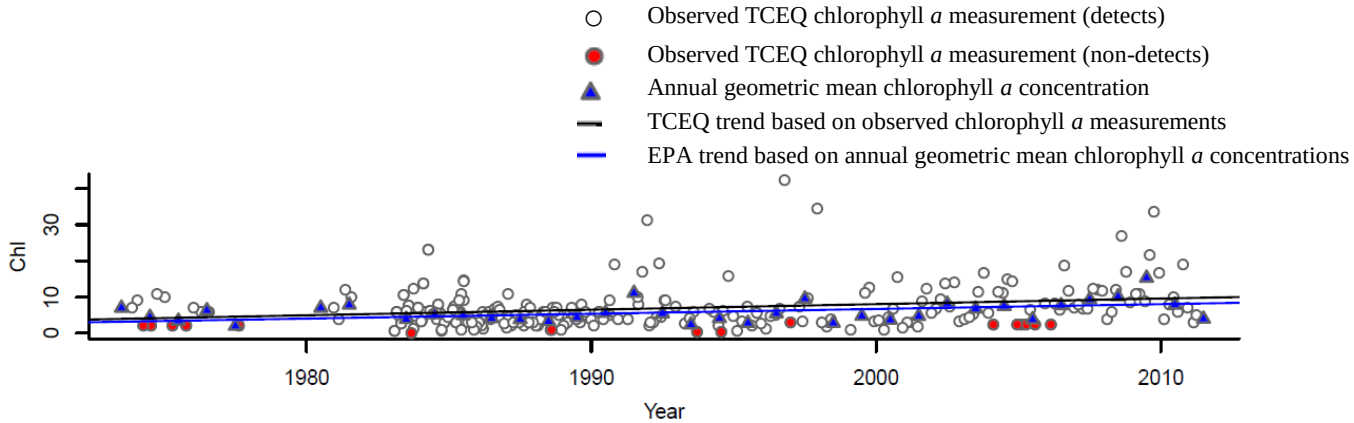
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 227 chlorophyll *a* measurements collected from Marble Falls Lake between 1973 and 2011 (see Figure 49). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Marble Falls Lake. Based upon the supporting information provided by TCEQ, a shift in methodology does appear to have occurred for this dataset in 2003 (with some data after 2003 being collected using the fluorometric method rather than the spectrophotometric method). Two hundred and five chlorophyll *a* measurements were made using the spectrophotometric method, with 11 of these measurements (~5%) being reported as less than the minimum reporting limits. Twenty-two measurements were made using the fluorometric method, with 5 of these measurements (~23%) being reported as less than the minimum reporting limits. When TCEQ analyzed trends for each of these datasets separately, the chlorophyll *a* data collected using the fluorometic method did not show a statistically significant increasing trend, while the chlorophyll *a* data collected using the spectrophotometric method did show a statistically significant increasing trend. In further analyzing the spectrophotometric method dataset, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) did not affect the statistical significance of this chlorophyll *a* trend to such a degree that the trend became statistically insignificant. Therefore, EPA believes that this increasing trend for Marble Falls Lake is statistically significant.

Figure 49. Chlorophyll *a* Trend for Marble Falls Lake Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Marble Falls Lake based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 50). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Marble Falls Lake, the magnitude of the slope of this increasing trend was relatively moderate at 0.133 µg/L chlorophyll *a*/year.

Figure 50. Chlorophyll *a* Trends for Marble Falls Lake Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Marble Falls Lake was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Marble Falls Lake between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 51.26 was determined for the 2010 reporting cycle for Marble Falls Lake.

This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 5.26 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Marble Falls Lake was eutrophic for both the 2000 and 2010 reporting cycles.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Marble Falls Lake, the chlorophyll *a* criterion is below 30 µg/L but 1% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Marble Falls Lake, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of Marble Falls Lake. Reservoir-specific data and information described above indicates a eutrophic classification for Marble Falls Lake, with a relatively moderate rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.133 µg/L chlorophyll *a*/year) and a statisticially significant increasing trend in chlorophyll *a* concentration based on EPA's review of TCEQ's trend analysis. TCEQ did not identify any CWA §303(d) listings for pH or DO for Marble Falls Lake, nor did it identify any concerns for nutrient or nutrient-enrichment related indicators. Further, only 1% of the measurements in the underlying chlorophyll *a* dataset available for Marble Falls Lake were greater than 30 µg/L. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 10.48 µg/L applicable to Marble Falls Lake is protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

26. <u>Possum Kingdom Lake, Segment 1207, Chlorophyll *a* Criterion 10.74 µg/L (Approved*)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 59 measurements collected between between August 21, 1990, and September 11, 2008. Of these 59 measurements, 5 were considered to be outliers because they had values greater than 21.7 µg/L. So, the criterion was derived using a final dataset consisting of 54 chlorophyll *a* measurements collected between between August 21, 1990, and September 11, 2008, all of which were equal to or below 18.6 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Possum Kingdom Lake.

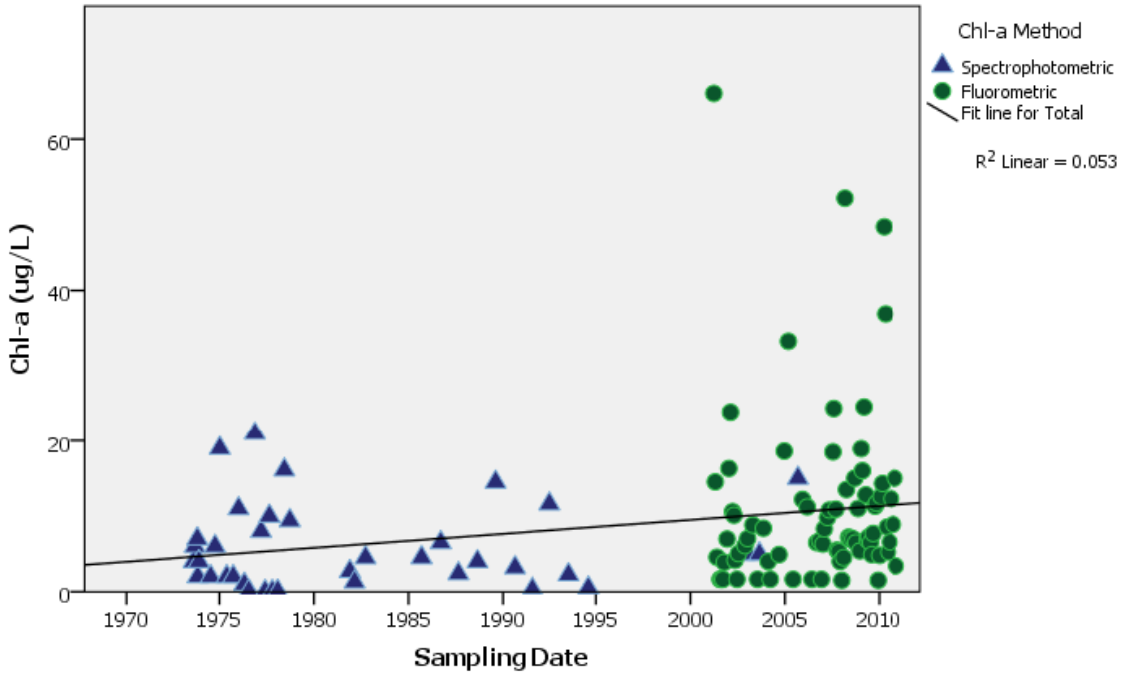
Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, no water quality concerns for any nutrient or nutrient enrichment-related indicators were identified for Possum Kingdom Lake.

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Possum Kingdom Lake in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Possum Kingdom Lake was not sampled as part of the 2007 NLA.

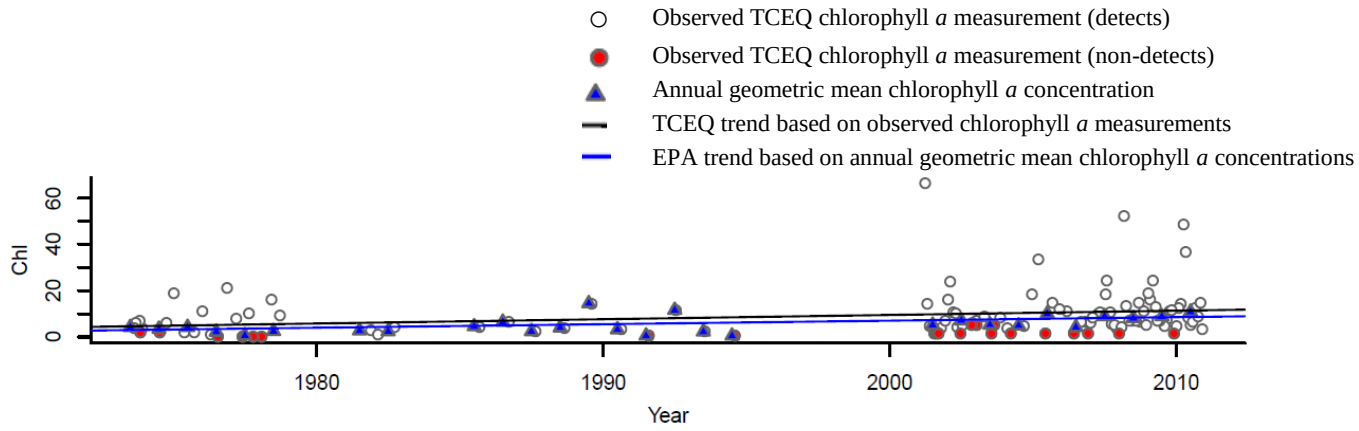
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 115 chlorophyll *a* measurements collected from Possum Kingdom Lake between 1973 and 2010 (see Figure 51). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Possum Kingdom Lake. Based upon the supporting information provided by TCEQ, a shift in methodology does appear to have occurred for this dataset in 2001 (most data after 2001 was collected using the fluorometric method rather than the spectrophotometric method). Thirty-eight chlorophyll *a* measurements were made using the spectrophotometric method, with 11 of these measurements (~29%) being reported as less than the minimum reporting limits. Seventy-seven measurements were made using the fluorometric method, with 11 of these measurements (14%) being reported as less than the minimum reporting limits. When TCEQ analyzed trends for each of these datasets separately, neither the chlorophyll *a* data collected using the spectrophotometric method nor the chlorophyll *a* data collected using the fluorometric method showed a statistically significant increasing trend.

Figure 51. Chlorophyll *a* Trend for Possum Kingdom Lake Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Possum Kingdom Lake based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 52). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Possum Kingdom Lake, the magnitude of the slope of this increasing trend was relatively moderate at 0.153 µg/L chlorophyll *a*/year.

Figure 52. Chlorophyll *a* Trends for Possum Kingdom Lake Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Possum Kingdom Lake was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Possum Kingdom Lake between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 50.36 was determined for the 2010 reporting cycle for Possum Kingdom Lake. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 8.17 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Possum Kingdom Lake shifted from a mesotrophic classification for the 2000 reporting cycle to a eutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Possum Kingdom Lake, the chlorophyll *a* criterion is below 30 µg/L but 3% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Possum Kingdom Lake, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of Possum Kingdom Lake. Reservoir-specific data and information described above indicates a mesotrophic classification for Possum Kingdom Lake in the 2000 reporting cycle with a shift to a eutrophic classification in the 2010 reporting cycle. Reservoir-specific data and information described above indicates a relatively moderate rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.153 µg/L chlorophyll *a*/year) and an increasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. Additionally, TCEQ did not identify any CWA §303(d) listings for pH or DO for Possum Kingdom Lake, nor did it identify any concerns for nutrient or nutrient-enrichment related indicators. Further, only 3% of the measurements in the underlying chlorophyll *a* dataset available for Possum Kingdom Lake were greater than 30 µg/L. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 10.74 µg/L applicable to Possum Kingdom Lake is protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

27. Lake Tyler East, Segment 0613, Chlorophyll *a* Criterion 10.88 µg/L (Approved)

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 51 measurements collected between between February 12, 1990, and October 13, 2008. Of these 51 measurements, 2 were considered to be outliers because they had values greater than 19 µg/L. So, the criterion was derived using a final dataset consisting of 49 chlorophyll *a* measurements collected between between February 12, 1990, and October 13, 2008, all of which were equal to or below 18.6 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for pH and DO listings in the 2000 through 2010 reporting cycles, the following 303(d) listings were identified for Lake Tyler East:

Year	Parameter	Assessment Unit	Assessment Unit Description
2000	low pH	n/a	(unclear description)
2002	low pH	n/a	Lake Tyler East upper reservoir

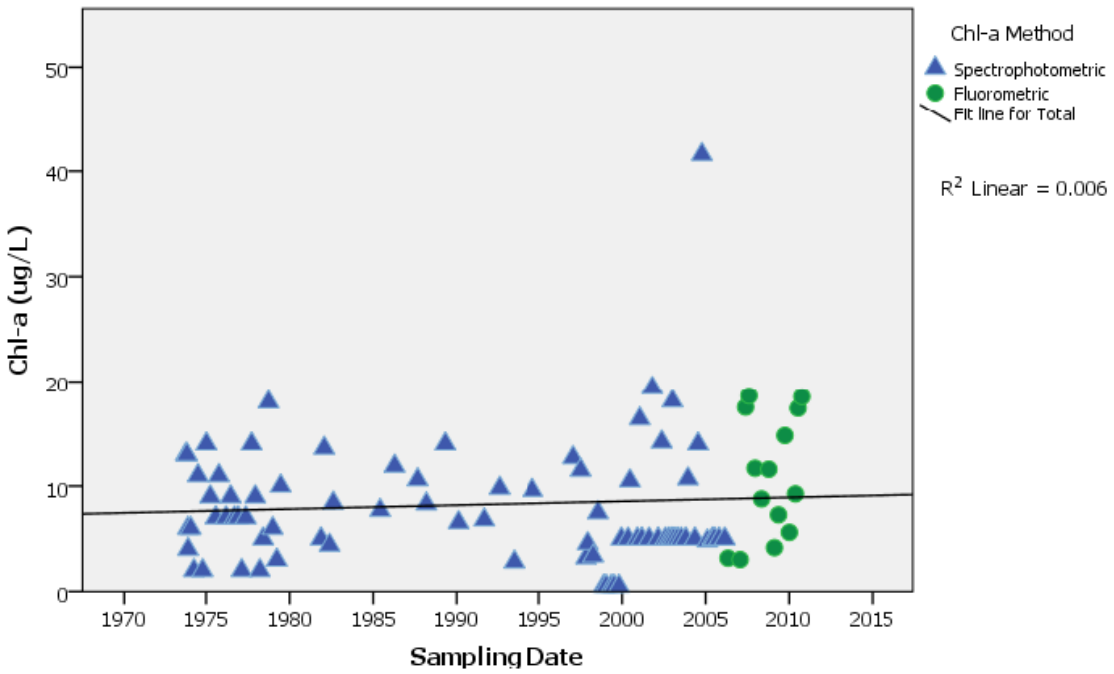
Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, no water quality concerns for any nutrient or nutrient enrichment-related indicators were identified for Lake Tyler East.

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Lake Tyler East in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Lake Tyler East was not sampled as part of the 2007 NLA.

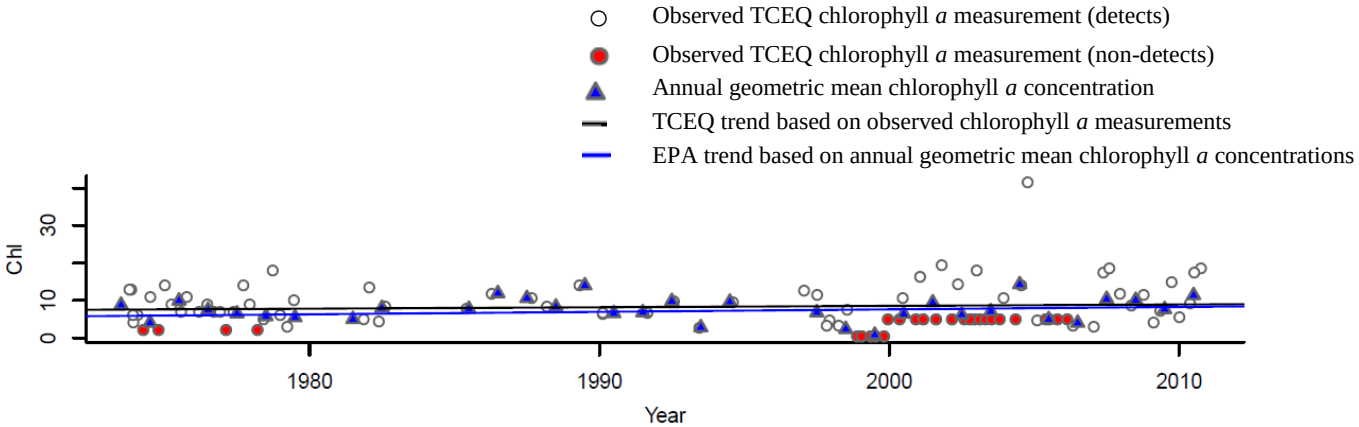
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ did not identify any statistically significant increasing trends in chlorophyll *a* concentrations for Lake Tyler East (see Figure 53).

Figure 53. Chlorophyll *a* Trend for Lake Tyler East Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Lake Tyler East based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 54). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Lake Tyler East, the magnitude of the slope of this increasing trend was relatively small at 0.066 µg/L chlorophyll *a*/year.

Figure 54. Chlorophyll *a* Trends for Lake Tyler East Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Lake Tyler East was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Lake Tyler East between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 50.98 was determined for the 2010 reporting cycle for Lake Tyler East. This value

was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 5.93 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Lake Tyler East was eutrophic for both the 2000 and 2010 reporting cycles.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Lake Tyler East, the chlorophyll *a* criterion is below 30 µg/L but 1% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Lake Tyler East, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of Lake Tyler East. Reservoir-specific data and information described above indicates a eutrophic classification for this reservoir, with a relatively small rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.066 µg/L chlorophyll *a*/year) and an increasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. Additionally, TCEQ only identified two CWA §303(d) listings for pH in Lake Tyler East in the 2000 and 2002 reporting cycles, and did not identify any concerns for nutrient or nutrient-enrichment related indicators. Further, only 1% of the measurements in the underlying chlorophyll *a* dataset available for Lake Tyler East were greater 30 µg/L. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 10.88 µg/L applicable to Lake Tyler East is protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

28. <u>Houston County Lake, Segment 0813, Chlorophyll *a* Criterion 11.10 µg/L (Approved)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 40 measurements collected between between July 30, 1990, and July 22, 2008. Of these 40 measurements, 5 were considered to be outliers because they had values greater than 22.3125 µg/L. So, the criterion was derived using a final dataset consisting of 35 chlorophyll *a* measurements collected between between July 30, 1990, and July 22, 2008, all of which were equal to or below 20 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Houston County Lake.

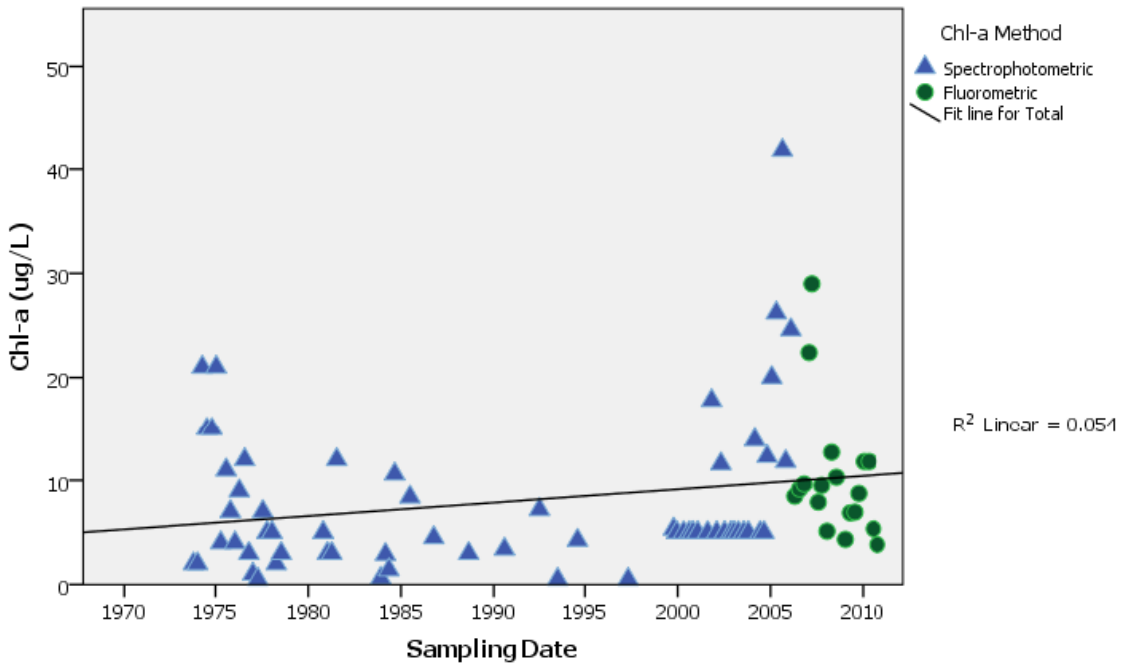
Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, no water quality concerns for any nutrient or nutrient enrichment-related indicators were identified for Houston County Lake.

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Houston County Lake in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Houston County Lake was not sampled as part of the 2007 NLA.

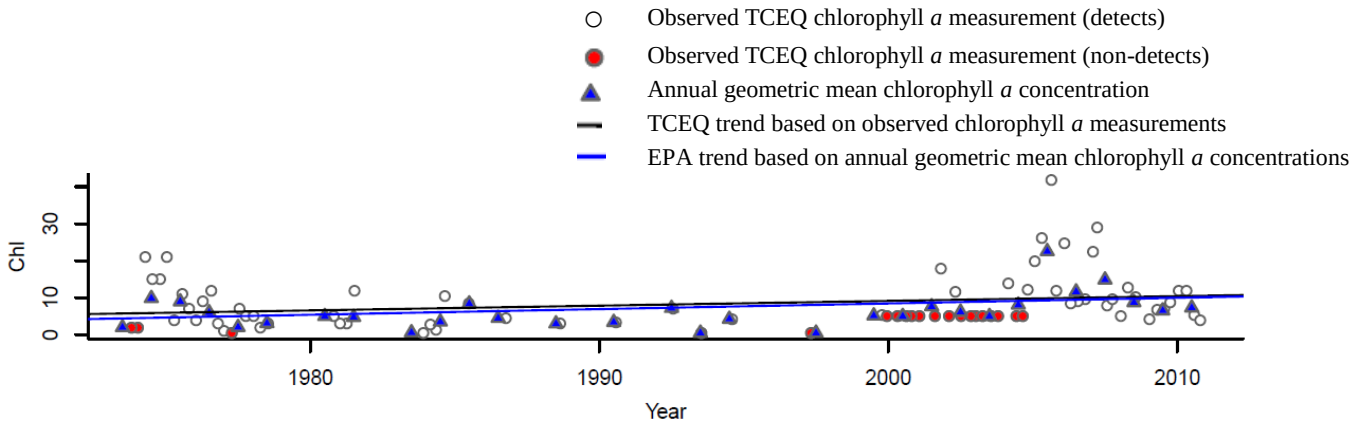
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 79 chlorophyll *a* measurements collected from Houston County Lake between 1973 and 2010 (see Figure 55). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Houston County Lake. Based upon the supporting information provided by TCEQ, a shift in methodology does appear to have occurred for this dataset in 2006 (all data after 2006 was collected using the fluorometric method rather than the spectrophotometric method). Sixty-one chlorophyll *a* measurements were made using the spectrophotometric method, with 20 of these measurements (~33%) being reported as less than the minimum reporting limits. Eighteen measurements were made using the fluorometric method, with none of these measurements (0%) being reported as less than the minimum reporting limits. When TCEQ analyzed trends for each of these datasets separately, neither the chlorophyll *a* data collected using the spectrophotometric method nor the chlorophyll *a* data collected using the fluorometric method showed a statistically significant increasing trend.

Figure 55. Chlorophyll *a* Trend for Houston County Lake Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Houston County Lake based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 56). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Houston County Lake, the magnitude of the slope of this increasing trend was relatively moderate at 0.153 µg/L chlorophyll *a*/year.

Figure 56. Chlorophyll *a* Trends for Houston County Lake Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Houston County Lake was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Houston County Lake between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 53.58 was determined for the 2010 reporting cycle for Houston County Lake. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 13.9 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Houston County Lake shifted from a mesotrophic classification for the 2000 reporting cycle to a eutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Houston County Lake, the chlorophyll *a* criterion is below 30 µg/L but 1% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Houston County Lake, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of Houston County Lake. Reservoir-specific data and information described above indicates a mesotrophic classification for Houston County Lake in the 2000 reporting cycle with a shift to a eutrophic classification in the 2010 reporting cycle. Reservoir-specific data and information described above indicates a relatively moderate rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.153 µg/L chlorophyll *a*/year) and an increasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. Additionally, TCEQ did not identify any CWA §303(d) listings for pH or DO for Houston County Lake, nor did it identify any concerns for nutrient or nutrient-enrichment related indicators. Further, only 1% of the measurements in the underlying chlorophyll *a* dataset available for Houston County Lake were greater than 30 µg/L. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 11.10 µg/L applicable to Houston County Lake is protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

29. Lake Arrowhead, Segment 0212, Chlorophyll *a* Criterion 11.21 µg/L (Disapproved)

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 52 measurements collected between between August 22, 1973, and June 10, 2008. Of these 52 measurements, 2 were considered to be outliers because they had values greater than 20.95 µg/L. So, the criterion was derived using a final dataset consisting of 50 chlorophyll *a* measurements collected between between August 22, 1973, and June 10, 2008, all of which were equal to or below 20.2 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Lake Arrowhead.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Lake Arrowhead:

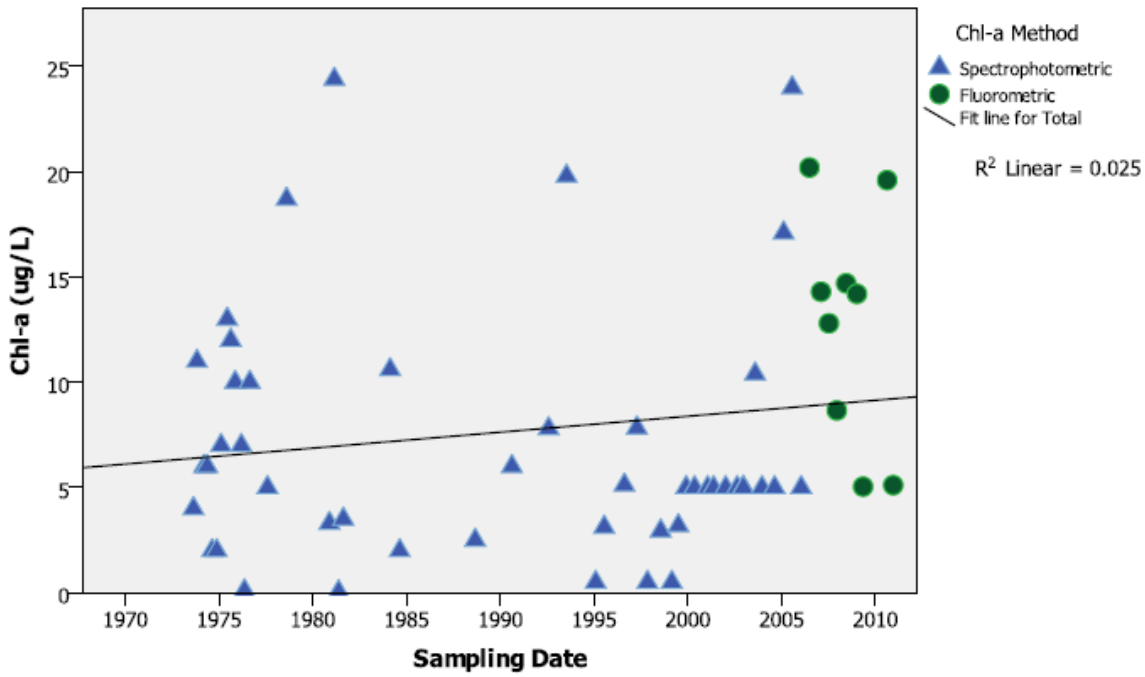
Year	Parameter	Assessment Unit	Assessment Unit Description
2006	OP	0212_01	Entire lake
2008	OP	0212_01	Entire lake
2010	OP	0212_01	Entire water body
2006	TP	0212_01	Entire lake
2008	TP	0212_01	Entire lake

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Lake Arrowhead in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Lake Arrowhead was not sampled as part of the 2007 NLA.

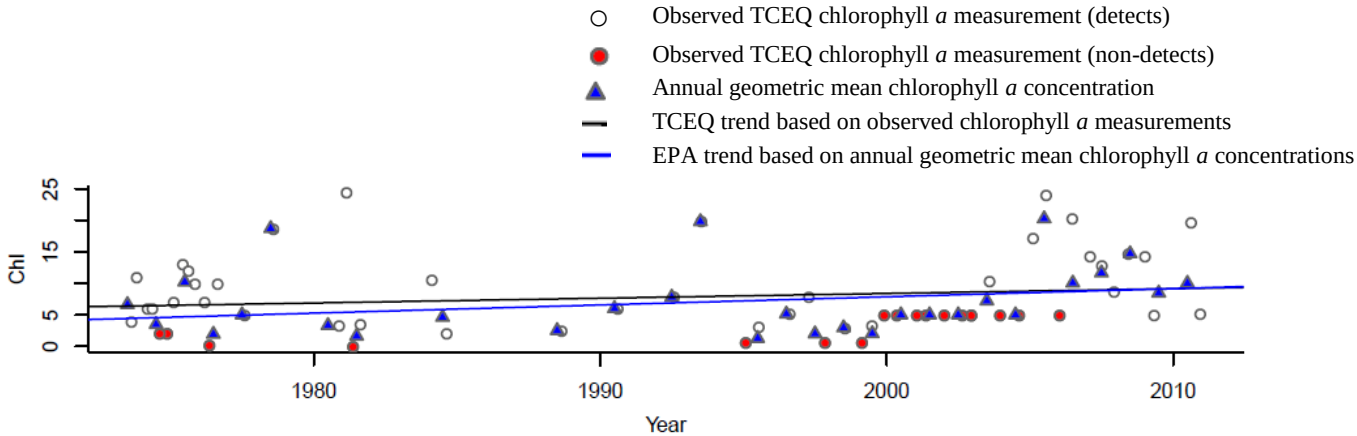
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ did not identify any statistically significant increasing trends in chlorophyll *a* concentrations for Lake Arrowhead (see Figure 57).

Figure 57. Chlorophyll *a* Trend for Lake Arrowhead Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Lake Arrowhead based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 58). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Lake Arrowhead, the magnitude of the slope of this increasing trend was relatively moderate at 0.130 µg/L chlorophyll *a*/year.

Figure 58. Chlorophyll *a* Trends for Lake Arrowhead Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Lake Arrowhead was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Lake Arrowhead between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 51.06 was determined for the 2010 reporting cycle for Lake Arrowhead. This

value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 7.99 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Lake Arrowhead shifted from a mesotrophic classification for the 2000 reporting cycle to a eutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Lake Arrowhead, the chlorophyll *a* criterion is below 30 µg/L and 0% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Lake Arrowhead, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is not satisfied in the case of Lake Arrowhead. Reservoir-specific data and information described above indicates a mesotrophic classification for Lake Arrowhead in the 2000 reporting cycle with a shift to a eutrophic classification in the 2010 reporting cycle. Reservoir-specific data and information described above indicates a relatively moderate rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.130 µg/L chlorophyll *a*/year) and an increasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. TCEQ did not identify any CWA §303(d) listings for pH or DO for Lake Arrowhead. However, TCEQ did identify five concerns for nutrients (OP and TP) in Lake Arrowhead that were repeating. OP was identified as a concern for the entire reservoir in the 2006 through 2010 reporting cycles, and TP was identified as a concern for the entire reservoir in the 2006 and 2008 reporting cycles. None of the measurements in the underlying chlorophyll *a* dataset available for Lake Arrowhead were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is not satisfied in the case of Lake Arrowhead, EPA strongly considered the relatively moderate rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.130 µg/L chlorophyll *a*/year) in combination with TCEQ's identification of five nutrient concerns that were repeating. These two information sources indicate both the presence of nutrients in concentrations of concern to TCEQ and a biological response in the form of a relatively moderate chlorophyll *a* accumulation rate. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 11.21 µg/L applicable to Lake Arrowhead is not protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA disapproves this reservoir-specific chlorophyll *a* criterion.

30. <u>B.A. Steinhagen Lake, Segment 0603, Chlorophyll *a* Criterion 11.67 µg/L (Approved)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 39 measurements collected between between June 12, 1990, and October 29, 2008. Of these 39 measurements, 1 was considered to be an outlier because it had a value greater than 20.5 µg/L. So, the criterion was derived using a final dataset consisting of 38 chlorophyll *a* measurements collected between between June 12, 1990, and October 29, 2008, all of which were equal to or below 17.6 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for B.A. Steinhagen Lake.

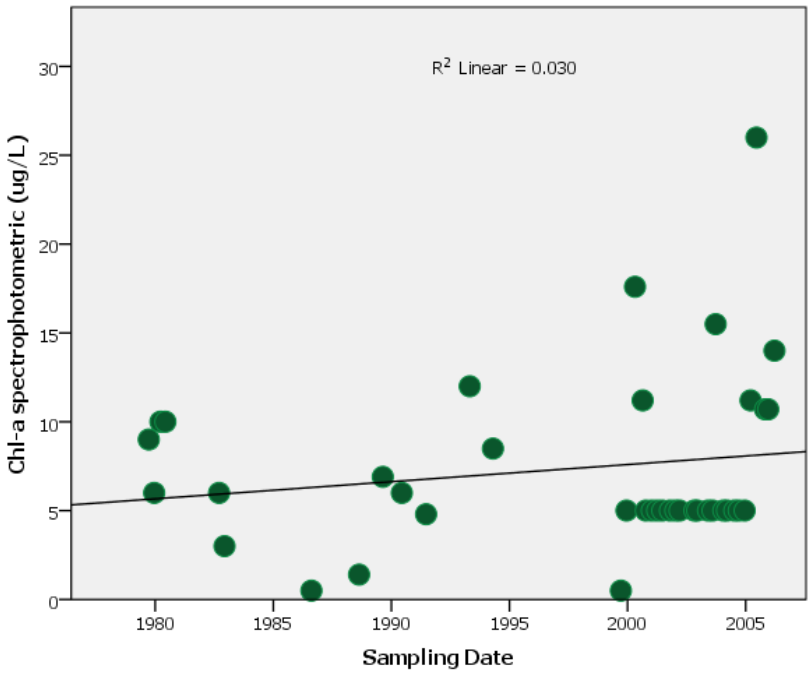
Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, no water quality concerns for any nutrient or nutrient enrichment-related indicators were identified for B.A. Steinhagen Lake.

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for B.A. Steinhagen Lake in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: B.A. Steinhagen Lake was not sampled as part of the 2007 NLA.

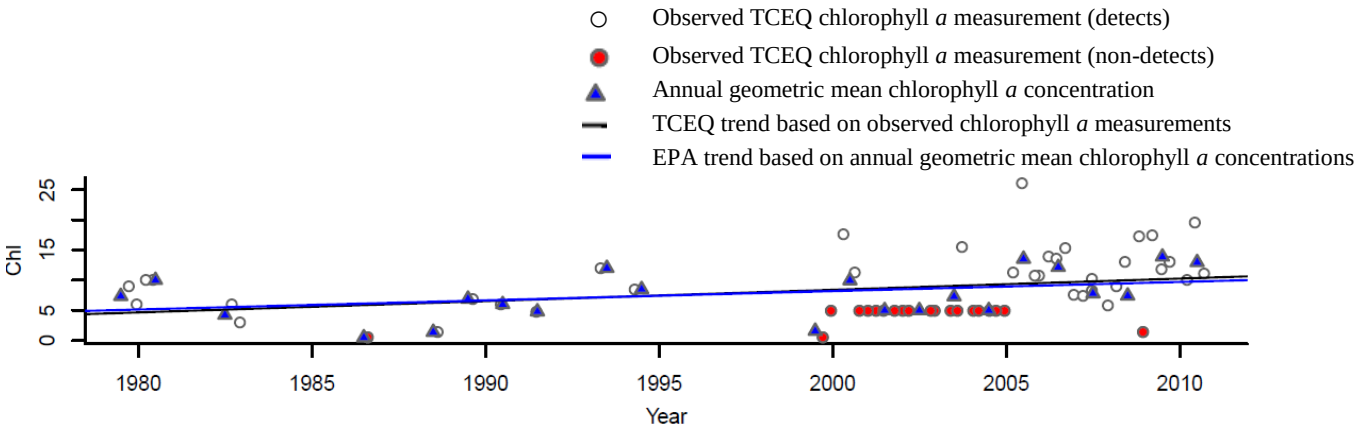
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ did not identify any statistically significant increasing trends in chlorophyll *a* concentrations for B.A. Steinhagen Lake (see Figure 59).

Figure 59. Chlorophyll *a* Trend for B.A. Steinhagen Lake Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for B.A. Steinhagen Lake based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 60). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For B.A. Steinhagen Lake, the magnitude of the slope of this increasing trend was relatively moderate at 0.152 µg/L chlorophyll *a*/year.

Figure 60. Chlorophyll *a* Trends for B.A. Steinhagen Lake Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: B.A. Steinhagen Lake was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for B.A. Steinhagen Lake between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 50.74 was determined for the 2010 reporting cycle for B.A. Steinhagen Lake. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 0.72 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that B.A. Steinhagen Lake was eutrophic for both the 2000 and 2010 reporting cycles.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For B.A. Steinhagen Lake, the chlorophyll *a* criterion is below 30 µg/L and 0% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for B.A. Steinhagen Lake, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of B.A. Steinhagen Lake. Reservoir-specific data and information described above indicates a eutrophic classification for B.A. Steinhagen Lake, with a relatively moderate rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.152 µg/L chlorophyll *a*/year) and an increasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. Additionally, TCEQ did not identify any CWA §303(d) listings for pH or DO for B.A. Steinhagen Lake, nor did it identify any concerns for nutrient or nutrient-enrichment related indicators. Further, none of the measurements in the underlying chlorophyll *a* dataset available for B.A. Steinhagen Lake were greater than 30 µg/L. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 11.67 µg/L applicable to B.A. Steinhagen Lake is protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

31. Granger Lake, Segment 1247, Chlorophyll *a* Criterion 11.72 µg/L (Disapproved)

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 73 measurements collected between between March 20, 1990, and September 16, 2008. Of these 73 measurements, 3 were considered to be outliers because they had values greater than 23.13 µg/L. So, the criterion was derived using a final dataset consisting of 70 chlorophyll *a* measurements collected between between March 20, 1990, and September 16, 2008, all of which were equal to or below 22 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Granger Lake.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Granger Lake:

Year	Parameter	Assessment Unit	Assessment Unit Description
2006	NO3-N	1247_01	Eastern end of lake near the dam
2008	NO3-N	1247_01	Eastern end of lake near the dam
2010	NO3-N	1247_01	Eastern end of lake near the dam
2006	NO3-N	1247_02	Willis Creek arm of lake
2008	NO3-N	1247_02	Willis Creek arm of lake
2010	NO3-N	1247_02	Willis Creek arm of lake
2006	NO3-N	1247_03	Western end of lake on the San Gabriel River
2008	NO3-N	1247_03	Western end of lake on the San Gabriel River
2010	NO3-N	1247_03	Western end of lake on the San Gabriel River

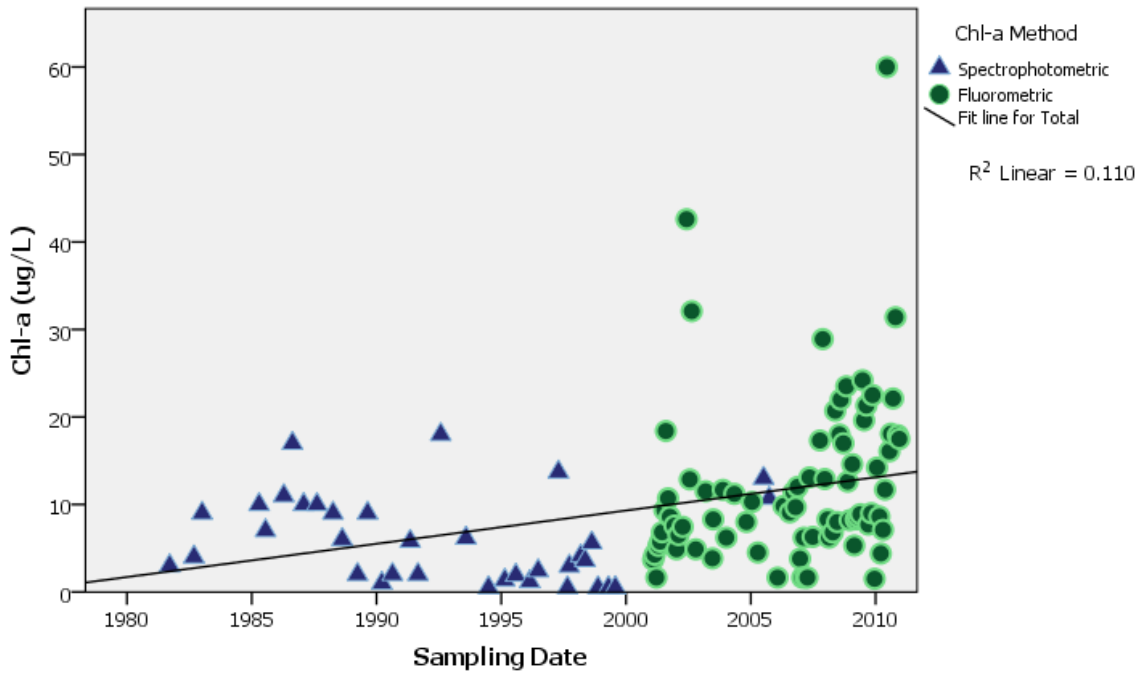
Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Granger Lake in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Granger Lake was not sampled as part of the 2007 NLA.

TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 113 chlorophyll *a* measurements collected from Granger Lake between 1981 and 2010 (see Figure 61). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Granger Lake. Based upon the supporting information provided by TCEQ, a shift in methodology does appear to have occurred for this dataset in 2001 (with most data after 2001 being collected using the fluorometric method rather than the spectrophotometric method). Thirty-five chlorophyll *a* measurements were made using the spectrophotometric method, with 6 of these measurements (~17%) being reported as less than the minimum reporting limits. Seventy-eight measurements were made using the fluorometric method, with 7 of these measurements (~9%) being reported as less than the minimum reporting limits. When TCEQ analyzed trends for each of these datasets separately, the chlorophyll *a* data collected using the spectrophotometric method did not show a statistically significant increasing trend, while the chlorophyll *a* data collected using the fluorometic method did show a statistically significant increasing trend. In further analyzing the fluorometric method

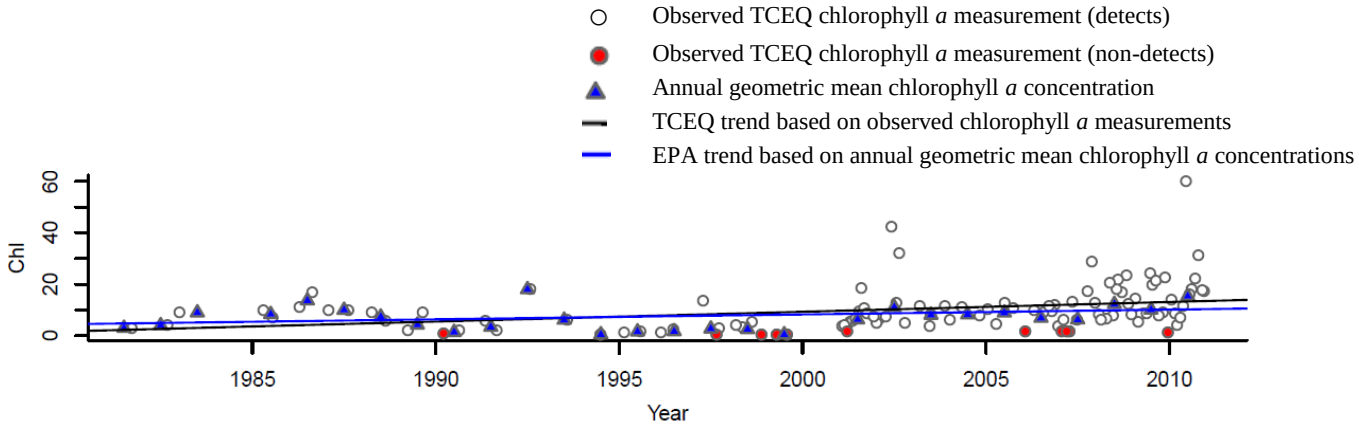
dataset, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) did not affect the statistical significance of this chlorophyll *a* trend to such a degree that the trend became statistically insignificant. Therefore, EPA believes that this increasing trend for Granger Lake is statistically significant.

Figure 61. Chlorophyll *a* Trend for Granger Lake Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Granger Lake based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 62). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Granger Lake, the magnitude of the slope of this increasing trend was relatively moderate at 0.189 µg/L chlorophyll *a*/year.

Figure 62. Chlorophyll *a* Trends for Granger Lake Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Granger Lake was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Granger Lake between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 48.46 was determined for the 2010 reporting cycle for Granger Lake. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 7.15 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Granger Lake shifted from a mesotrophic classification for the 2000 reporting cycle to a eutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Granger Lake, the chlorophyll *a* criterion is below 30 µg/L but 2% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Granger Lake, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is not satisfied in the case of Granger Lake. Reservoir-specific data and information described above indicates a mesotrophic classification for Granger Lake in the 2000 reporting cycle with a shift to a eutrophic classification in the 2010 reporting cycle. Reservoir-specific data and information described above indicates a relatively moderate rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.189 µg/L chlorophyll *a*/year) and a statistically significant increasing trend in chlorophyll *a* concentration based on EPA's review of TCEQ's trend analysis. TCEQ did not identify any CWA §303(d) listings for pH or DO for Granger Lake. However, TCEQ did identify nine concerns for nutrients (NO3-N) in Granger Lake that were repeating. NO3-N was identified as a concern in the 2006 through 2010 reporting cycles in each of the three assessment units for Granger Lake (i.e., the entire reservoir). 2% of the measurements in the underlying chlorophyll *a* dataset available for Granger Lake were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is not satisfied in the case of Granger Lake, EPA strongly considered the relatively moderate rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.189 µg/L chlorophyll *a*/year) in combination with TCEQ's identification of nine nutrient concerns that were repeating. These two information sources indicate both the presence of nutrients in concentrations of concern to TCEQ and a biological response in the form of a relatively moderate chlorophyll *a* accumulation rate. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 11.72 µg/L applicable to Granger Lake is not protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA disapproves this reservoir-specific chlorophyll *a* criterion.

32. <u>Grapevine Lake, Segment 0826, Chlorophyll *a* Criterion 11.90 µg/L (Disapproved)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 54 measurements collected between between May 17, 1972, and October 30, 2001. Of these 54 measurements, 2 should have been considered outliers because they had values greater than 21.0875 µg/L. However, 1 of these outliers (23.3 µg/L) was inadvertently included in the final dataset. So, the criterion was derived using a final dataset consisting of 53 chlorophyll *a* measurements collected between between May 17, 1972, and October 30, 2001, all of which were equal to or below 23.3 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Grapevine Lake.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Grapevine Lake:

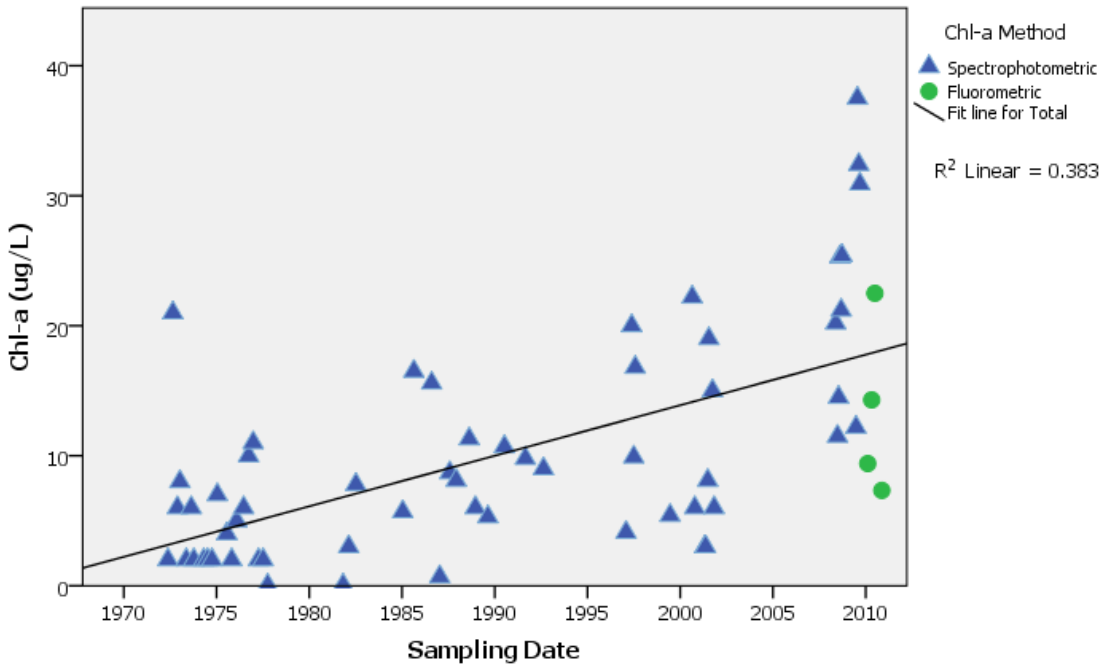
Year	Parameter	Assessment Unit	Assessment Unit Description
2008	NO3-N	0826_01	Lowermost portion of reservoir
2006	NO3-N	0826_05	Middle portion of reservoir east of Meadowmere Park
2008	NO3-N	0826_05	Middle portion of reservoir east of Meadowmere Park
2006	NO3-N	0826_06	Middle portion of reservoir southeast of Walnut Grove Park
2008	NO3-N	0826_06	Middle portion of reservoir southeast of Walnut Grove Park
2006	NO3-N	0826_07	Upper portion of reservoir east of Marshall Creek Park
2008	NO3-N	0826_07	Upper portion of reservoir east of Marshall Creek Park
2010	NO3-N	0826_07	Upper portion of reservoir east of Marshall Creek Park

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Grapevine Lake in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Grapevine Lake was not sampled as part of the 2007 NLA.

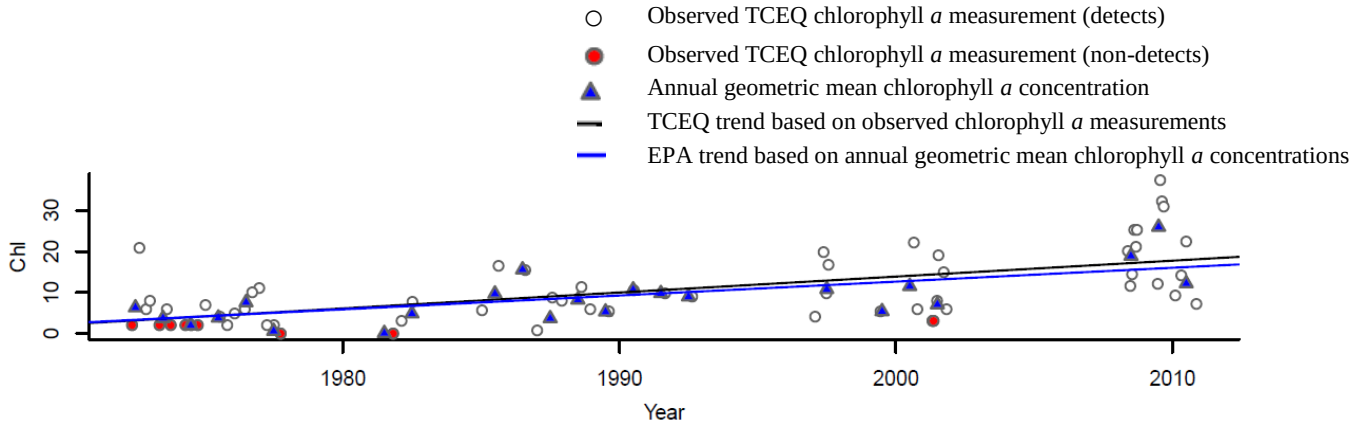
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 62 chlorophyll *a* measurements collected from Grapevine Lake between 1972 and 2010 (see Figure 63). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Grapevine Lake. Based upon the supporting information provided by TCEQ, a shift in methodology does appear to have occurred for this dataset in 2010 (with all data after 2010 being collected using the fluorometric method rather than the spectrophotometric method). Fifty-eight chlorophyll *a* measurements were made using the spectrophotometric method, with 10 of these measurements (~17%) being reported as less than the minimum reporting limits. Four measurements were made using the fluorometric method, with none of these measurements (0%) being reported as less than the minimum reporting limits. When TCEQ analyzed trends for each of these datasets separately, the chlorophyll *a* data collected using the fluorometic method did not show a statistically significant increasing trend, while the chlorophyll *a* data collected using the spectrophotometric method did show a statistically significant increasing trend. In further analyzing the spectrophotometric method dataset, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) did not affect the statistical significance of this chlorophyll *a* trend to such a degree that the trend became statistically insignificant. Therefore, EPA believes that this increasing trend for Grapevine Lake is statistically significant.

Figure 63. Chlorophyll *a* Trend for Grapevine Lake Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Grapevine Lake based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 64). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Grapevine Lake, the magnitude of the slope of this increasing trend was relatively high at 0.339 µg/L chlorophyll *a*/year.

Figure 64. Chlorophyll *a* Trends for Grapevine Lake Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Lake Grapevine was not included in TCEQ's report titled *Trophic Classification of Texas Reservoirs*.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix

and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Grapevine Lake, the chlorophyll *a* criterion is below 30 µg/L and 0% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Grapevine Lake, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is not satisfied in the case of Grapevine Lake. Trophic state classification information was not available for Grapevine Lake. Reservoir-specific data and information described above indicates a relatively high rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.339 µg/L chlorophyll *a*/year) and a statistically significant increasing trend in chlorophyll *a* concentration based on EPA's review of TCEQ's trend analysis. TCEQ did not identify any CWA §303(d) listings for pH or DO for Grapevine Lake. However, TCEQ did identify eight concerns for nutrients (NO3-N) in Grapevine Lake that were repeating. None of the measurements in the underlying chlorophyll *a* dataset available for Grapevine Lake were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is not satisfied in the case of Grapevine Lake, EPA strongly considered the relatively high rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.339 µg/L chlorophyll *a*/year) in combination with TCEQ's identification of eight nutrient concerns that were repeating. These two information sources indicate both the presence of nutrients in concentrations of concern to TCEQ and a biological response in the form of a relatively high chlorophyll *a* accumulation rate. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 11.90 µg/L applicable to Grapevine Lake is not protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA disapproves this reservoir-specific chlorophyll *a* criterion.

33. <u>Choke Canyon Reservoir, Segment 2116, Chlorophyll *a* Criterion 12.05 µg/L (Approved*)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 32 measurements collected between between November 17, 1983, and November 16, 1993. Of these 32 measurements, none were considered to be outliers because none had values greater than 21.875 µg/L. So, the criterion was derived using a final dataset consisting of 32 chlorophyll *a* measurements collected between between November 17, 1983, and November 16, 1993, all of which were equal to or below 19 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for pH and DO listings in the 2000 through 2010 reporting cycles, the following 303(d) listings were identified for Choke Canyon Reservoir:

Year	Parameter	Assessment Unit	Assessment Unit Description
2006	DO	2116_06	Western end of lake up to RR 99 bridge
2008	DO	2116_06	Western end of lake up to RR 99 bridge
2010	DO	2116_06	Western end of lake up to RR 99 bridge

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Choke Canyon Reservoir:

Year	Parameter	Assessment Unit	Assessment Unit Description
2008	DO	2116_05	Southern arm near mid lake and Rec. Road 7 west of Calliham
2010	DO	2116_05	Southern arm near mid lake and Rec. Road 7 west of Calliham
2006	DO	2116_06	Western end of lake up to RR 99 bridge

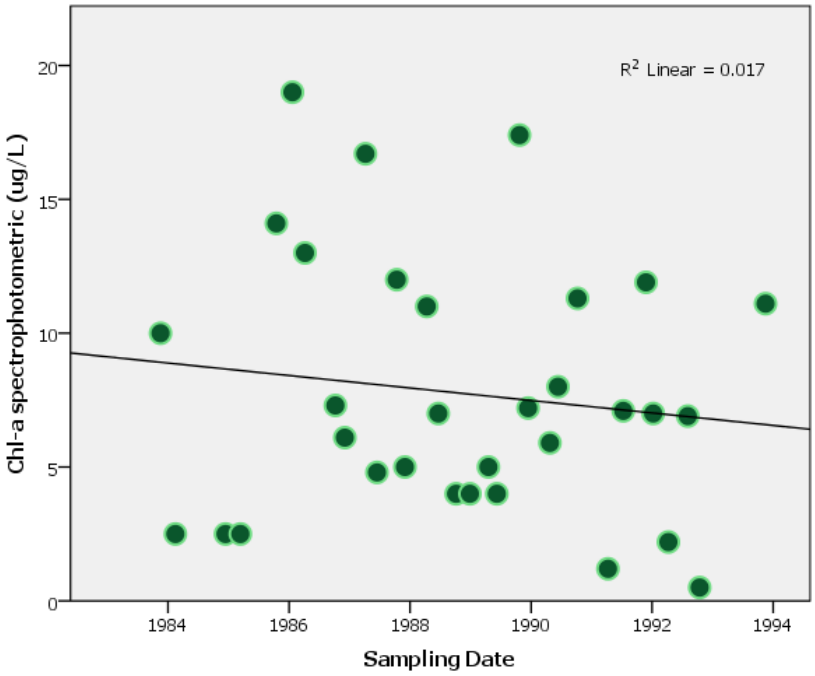
Year	Parameter	Assessment Unit	Assessment Unit Description
2008	DO	2116_06	Western end of lake up to RR 99 bridge
2010	DO	2116_06	Western end of lake up to RR 99 bridge

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Choke Canyon Reservoir in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Choke Canyon Reservoir was sampled one time as part of the 2007 NLA. The chlorophyll *a* concentration measured during sampling was 15.12 µg/L, indicating a moderate risk of exposure based on the chlorophyll *a* thresholds used in the NLA study. The microcystin concentration during sampling was below the reporting limit of 0.1 µg/L, indicating a low risk of exposure based on the microcystin thresholds used in the NLA study. The cyanobacteria cell count during sampling was less than 20,000 cells per milliliter, indicating a low risk of exposure based on the cyanobacteria thresholds used in the NLA study.

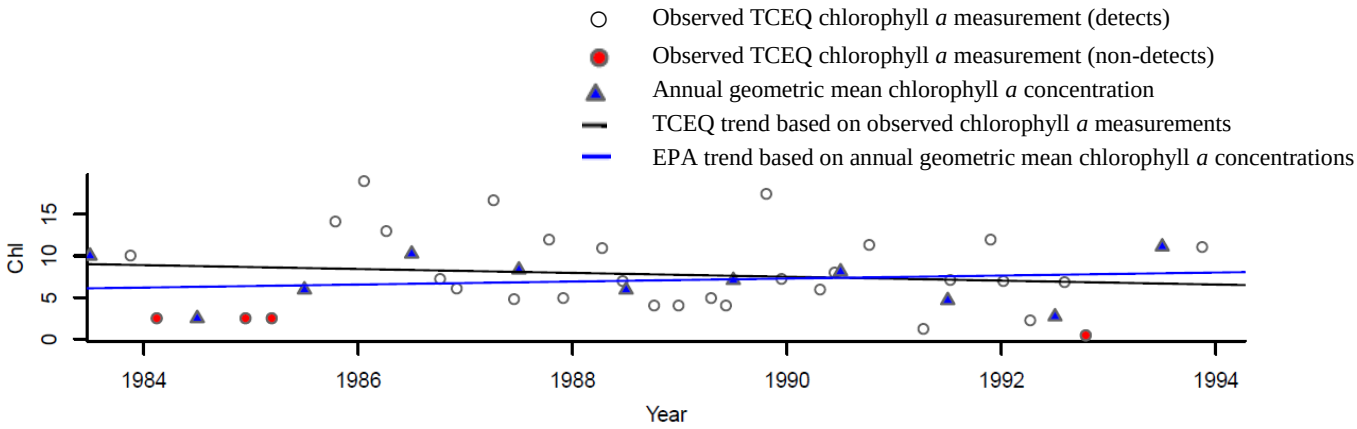
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ did not identify any statistically significant increasing trends in chlorophyll *a* concentrations for Choke Canyon Reservoir (see Figure 65).

Figure 65. Chlorophyll *a* Trend for Choke Canyon Reservoir Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Choke Canyon Reservoir based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 66). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Choke Canyon Reservoir, the magnitude of the slope of this increasing trend was relatively moderate at 0.181 µg/L chlorophyll *a*/year.

Figure 66. Chlorophyll *a* Trends for Choke Canyon Reservoir Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Choke Canyon Reservoir was not included in TCEQ's report titled *Trophic Classification of Texas Reservoirs*.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Choke Canyon Reservoir, the chlorophyll *a* criterion is below 30 µg/L and 0% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Choke Canyon Reservoir, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of Choke Canyon Reservoir. Trophic state classification information was not available for Choke Canyon Reservoir. Reservoir-specific data and information described above indicates a relatively moderate rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.181 µg/L chlorophyll *a*/year) and a decreasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. TCEQ identified three CWA §303(d) listings and three concerns for DO in the western end of Choke Canyon Reservoir in the 2006 through 2010 reporting cycles, as well as two additional concerns for DO in the southern arm of the reservoir in the 2008 and 2010 reporting cycles. However, TCEQ did not identify concerns for any other nutrient-enrichment related indicators or any nutrient indicators. 2007 NLA data indicated a moderate risk of exposure based on chlorophyll *a* thresholds and a low risk of exposure based on microcystin and cyanobacteria thresholds. Further, none of the measurements in the underlying chlorophyll *a* dataset available for Choke Canyon Reservoir were greater than 30 µg/L. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 12.05 µg/L applicable to Choke Canyon Reservoir is protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

34. <u>Pat Mayse Lake, Segment 0209, Chlorophyll *a* Criterion 12.40 µg/L (Approved*)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 41 measurements collected between between October 25, 1973, and March 8, 2000. Of these 41 measurements, 2 were considered to be outliers because they had values greater than 23.09 µg/L. So, the criterion was derived using a final dataset consisting of 39 chlorophyll *a*

measurements collected between between October 25, 1973, and March 8, 2000, all of which were equal to or below 21 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Pat Mayse Lake.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Pat Mayse Lake:

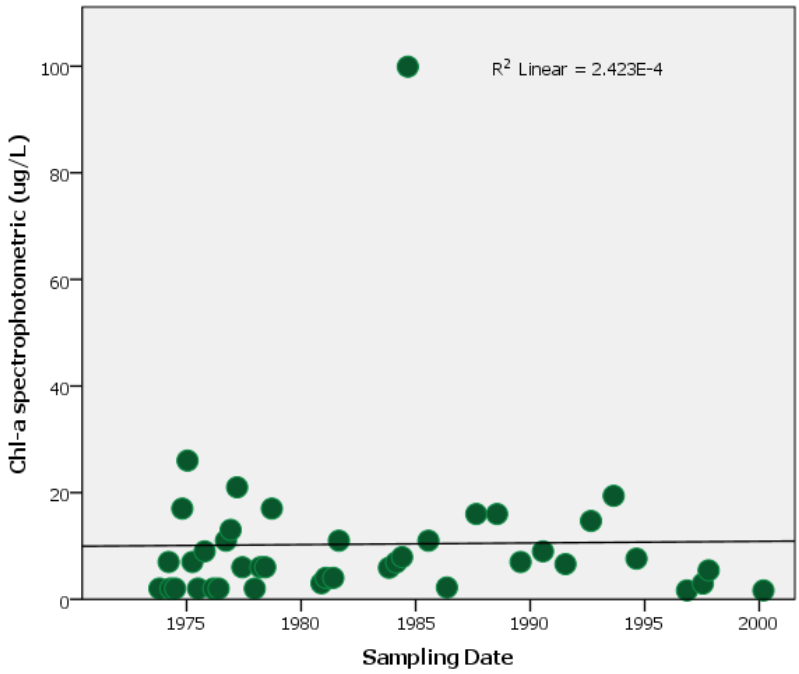
Year	Parameter	Assessment Unit	Assessment Unit Description
2010	Chl-a	0209_02	Upper half of lake

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Pat Mayse Lake in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Pat Mayse Lake was not sampled as part of the 2007 NLA.

TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ did not identify any statistically significant increasing trends in chlorophyll *a* concentrations for Pat Mayse Lake (see Figure 67).

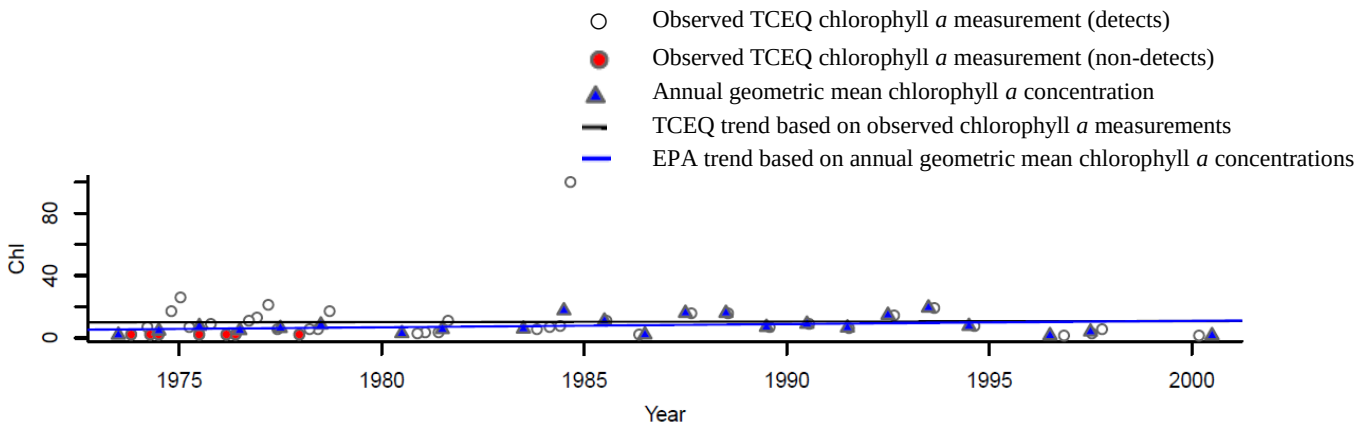
Figure 67. Chlorophyll *a* Trend for Pat Mayse Lake Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Pat Mayse Lake based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend

analysis (see Figure 68). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Pat Mayse Lake, the magnitude of the slope of this increasing trend was relatively high at 0.206 µg/L chlorophyll *a*/year.

Figure 68. Chlorophyll *a* Trends for Pat Mayse Lake Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Pat Mayse Lake was not included in TCEQ's report titled *Trophic Classification of Texas Reservoirs*.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Pat Mayse Lake, the chlorophyll *a* criterion is below 30 µg/L but 2% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Pat Mayse Lake, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of Pat Mayse Lake. Trophic state classification information was not available for Pat Mayse Lake. Reservoir-specific data and information described above indicates a relatively high rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.206 µg/L chlorophyll *a*/year) and an increasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. However, TCEQ did not identify any CWA §303(d) listings for pH or DO for Pat Mayse Lake, and only identified one concern for chlorophyll *a* in the upper half of the reservoir in the 2010 reporting cycle. TCEQ did not identify concerns for any other nutrient-enrichment related indicators or any nutrient indicators. Further, only 2% of the measurements in the underlying chlorophyll *a* dataset available for Pat Mayse Lake were greater than 30 µg/L. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 12.40 µg/L applicable to Pat Mayse Lake is protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

35. <u>Lake Sweetwater, Segment 1237, Chlorophyll *a* Criterion 13.28 µg/L (Disapproved)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 41 measurements collected between between August 29, 1973, and August 5, 1998. Of these 41 measurements, 4 were considered to be outliers because they had values greater than 25 µg/L. So, the criterion was derived using a final dataset consisting of 37 chlorophyll *a* measurements

collected between between August 29, 1973, and August 5, 1998, all of which were equal to or below 20 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Lake Sweetwater.

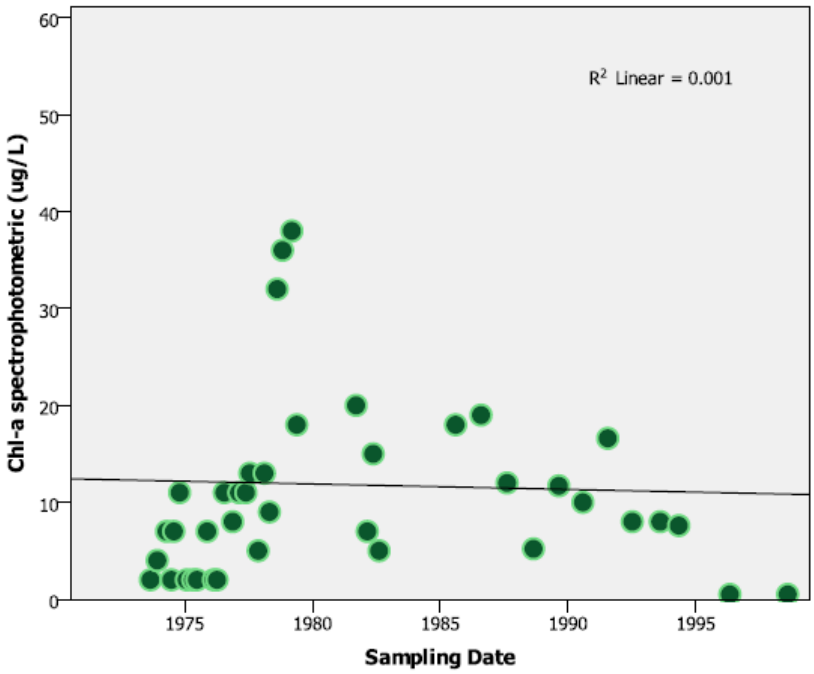
Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, no water quality concerns for any nutrient or nutrient enrichment-related indicators in Lake Sweetwater.

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Lake Sweetwater in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Lake Sweetwater was not sampled as part of the 2007 NLA.

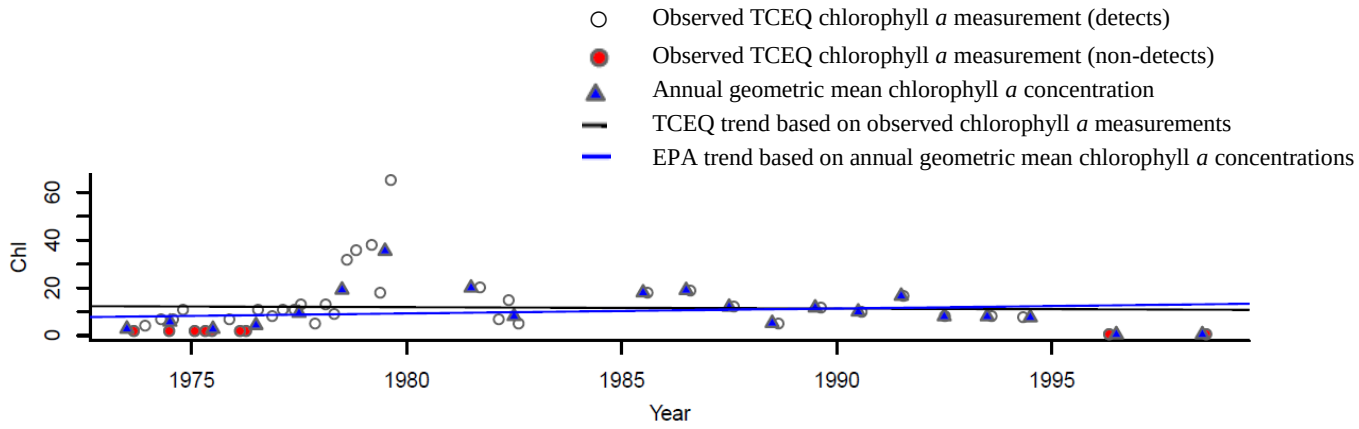
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ did not identify any statistically significant increasing trends in chlorophyll *a* concentrations for Lake Sweetwater (see Figure 69).

Figure 69. Chlorophyll *a* Trend for Lake Sweetwater Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Lake Sweetwater based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 70). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Lake Sweetwater, the magnitude of the slope of this increasing trend was relatively high at 0.206 µg/L chlorophyll *a*/year.

Figure 70. Chlorophyll *a* Trends for Lake Sweetwater Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Lake Sweetwater was not included in TCEQ's report titled *Trophic Classification of Texas Reservoirs*.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Lake Sweetwater, the chlorophyll *a* criterion is below 30 µg/L but 10% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Lake Sweetwater, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is not satisfied in the case of Lake Sweetwater. Trophic state classification information was not available for Lake Sweetwater. Reservoir-specific data and information described above indicates a relatively high rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.206 µg/L chlorophyll *a*/year) and a decreasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. TCEQ did not identify any CWA §303(d) listings for pH or DO for Lake Sweetwater, nor did it identify any concerns for nutrient or nutrient-enrichment related indicators. However, 10% of the measurements in the underlying chlorophyll *a* dataset available for Lake Sweetwater were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is not satisfied in the case of Lake Sweetwater, EPA strongly considered this last information source. With 10% of the measurements in the underlying chlorophyll *a* dataset available for Lake Sweetwater being greater than 30 µg/L, EPA is concerned that the chlorophyll *a* criterion (which is derived and expressed as a long-term central tendency), is not likely to protect designated uses from the effects of high instantaneous chlorophyll *a* concentrations (such as nuisance blooms, toxic cyanobacteria and toxin production, taste and odor compound production, and disinfection byproduct production). Based on the above information, EPA concludes that the chlorophyll *a* criterion of 13.28 µg/L applicable to Lake Sweetwater is not protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA disapproves this reservoir-specific chlorophyll *a* criterion.

36. <u>Lake Tyler, Segment 0613, Chlorophyll *a* Criterion 13.38 µg/L (Approved)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 41 measurements collected between between August 27, 1991, and October 13, 2008. Of these 41 measurements, 1 was considered to be an outlier because it had a value greater than

23.75 µg/L. So, the criterion was derived using a final dataset consisting of 40 chlorophyll *a* measurements collected between between August 27, 1991, and October 13, 2008, all of which were equal to or below 23.6 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Lake Tyler.

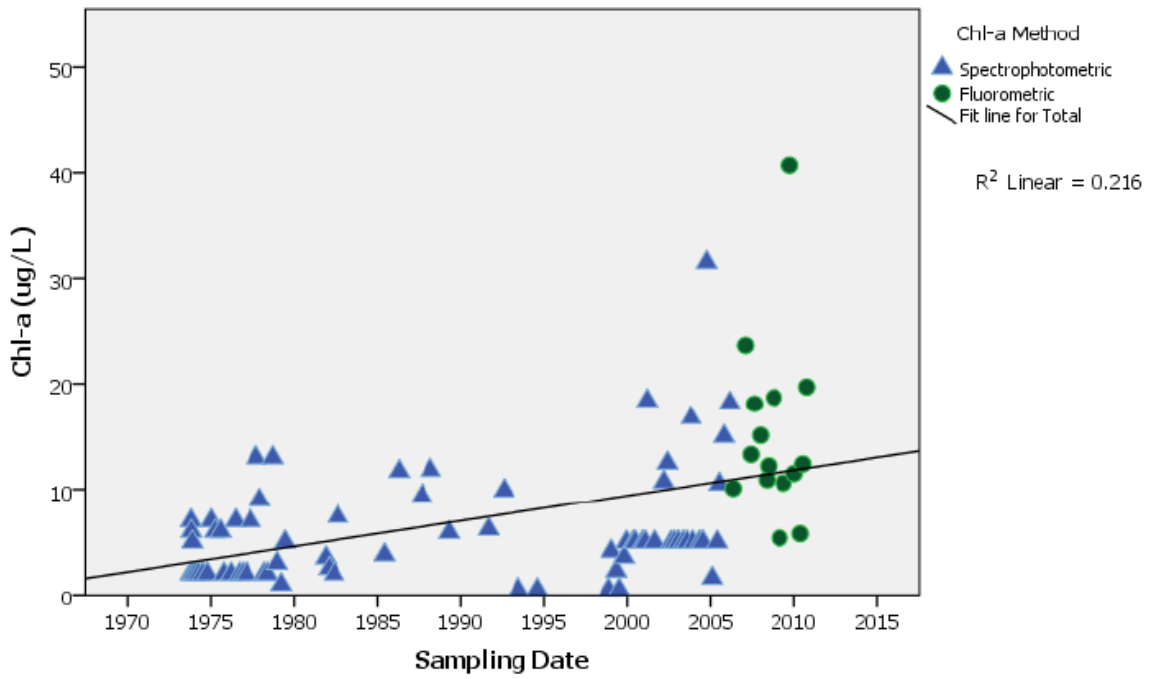
Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, no water quality concerns for any nutrient or nutrient enrichment-related indicators were identified for Lake Tyler.

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Lake Tyler in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Lake Tyler was not sampled as part of the 2007 NLA.

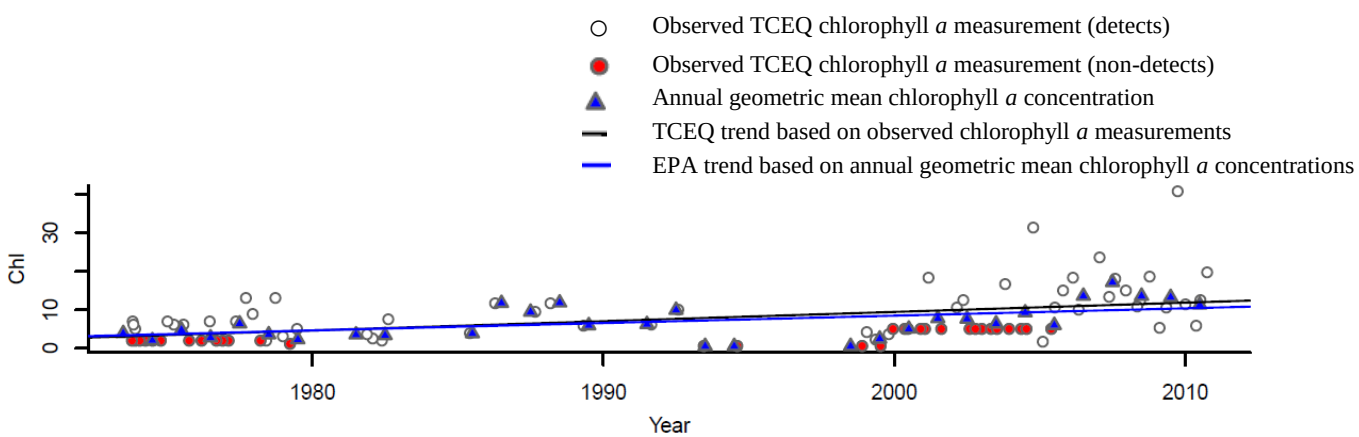
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 84 chlorophyll *a* measurements collected from Lake Tyler between 1973 and 2010 (see Figure 71). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Lake Tyler. Based upon the supporting information provided by TCEQ, a shift in methodology does appear to have occurred for this dataset in 2006 (with all data after 2006 being collected using the fluorometric method rather than the spectrophotometric method). Sixty-nine chlorophyll *a* measurements were made using the spectrophotometric method, with 32 of these measurements (~46%) being reported as less than the minimum reporting limits. Fifteen measurements were made using the fluorometric method, with none of these measurements (0%) being reported as less than the minimum reporting limits. When TCEQ analyzed trends for each of these datasets separately, the chlorophyll *a* data collected using the fluorometic method did not show a statistically significant increasing trend, while the chlorophyll *a* data collected using the spectrophotometric method did show a statistically significant increasing trend. In further analyzing the spectrophotometric method dataset, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) affected the statistical significance of this chlorophyll *a* trend to such a degree that the increasing trend for Lake Tyler was no longer considered statistically significant.

Figure 71. Chlorophyll *a* Trend for Lake Tyler Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Lake Tyler based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 72). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Lake Tyler, the magnitude of the slope of this increasing trend was relatively moderate at 0.192 µg/L chlorophyll *a*/year.

Figure 72. Chlorophyll *a* Trends for Lake Tyler Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Lake Tyler was not included in TCEQ's report titled *Trophic Classification of Texas Reservoirs*.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix

and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Lake Tyler, the chlorophyll *a* criterion is below 30 µg/L but 1% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Lake Tyler, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of Lake Tyler. Trophic state classification information was not available for Lake Tyler. Reservoir-specific data and information described above indicates a relatively moderate rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.192 µg/L chlorophyll *a*/year) and an increasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. Additionally, TCEQ did not identify any CWA §303(d) listings for pH or DO for Lake Tyler, nor did it identify any concerns for nutrient or nutrient-enrichment related indicators. Further, only 1% of the measurements in the underlying chlorophyll *a* dataset available for Lake Tyler were greater than 30 µg/L. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 13.38 µg/L applicable to Lake Tyler is protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

37. <u>Cox Lake, Segment 2454, Chlorophyll *a* Criterion 13.56 µg/L (Disapproved)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 46 measurements collected between between October 16, 1991, and December 4, 2008. Of these 46 measurements, 4 were considered to be outliers because they had values greater than 25.375 µg/L. So, the criterion was derived using a final dataset consisting of 42 chlorophyll *a* measurements collected between between April 29, 1992, and December 4, 2008, all of which were equal to or below 23.7 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Cox Lake.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Cox Lake:

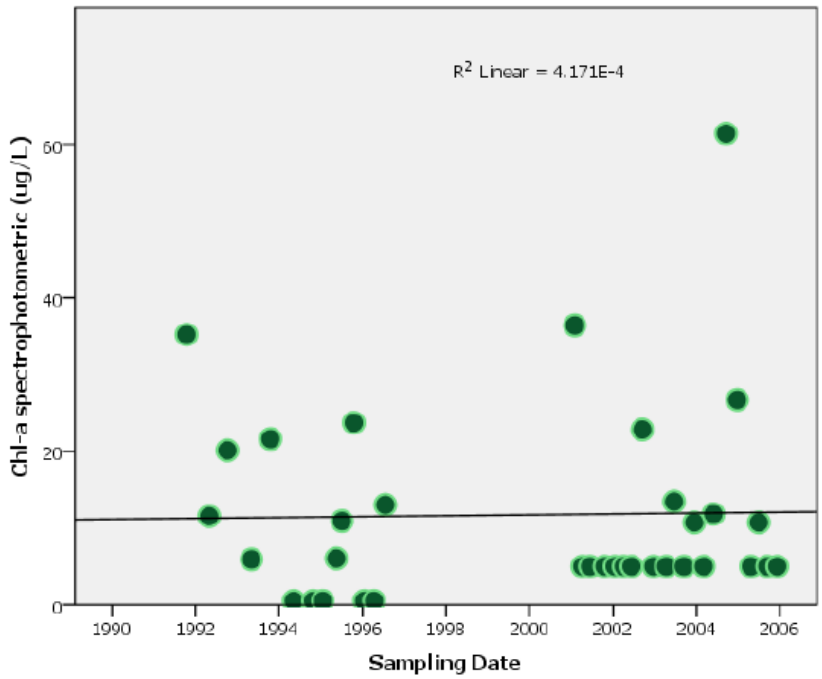
Year	Parameter	Assessment Unit	Assessment Unit Description
2006	Chl-a	2454A_01	Entire water body
2008	Chl-a	2454A_01	Entire water body
2006	NO3-N	2454A_01	Entire water body
2008	NO3-N	2454A_01	Entire water body
2010	NO3-N	2454A_01	From the Cox Lake dam located 4.0 km (2.5 mi) southeast of Point Comfort to the Calhoun/Jackson County line
2010	OP	2454A_01	From the Cox Lake dam located 4.0 km (2.5 mi) southeast of Point Comfort to the Calhoun/Jackson County line
2006	TP	2454A_01	Entire water body
2008	TP	2454A_01	Entire water body
2010	TP	2454A_01	From the Cox Lake dam located 4.0 km (2.5 mi) southeast of Point Comfort to the Calhoun/Jackson County line

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Cox Lake in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Cox Lake was not sampled as part of the 2007 NLA.

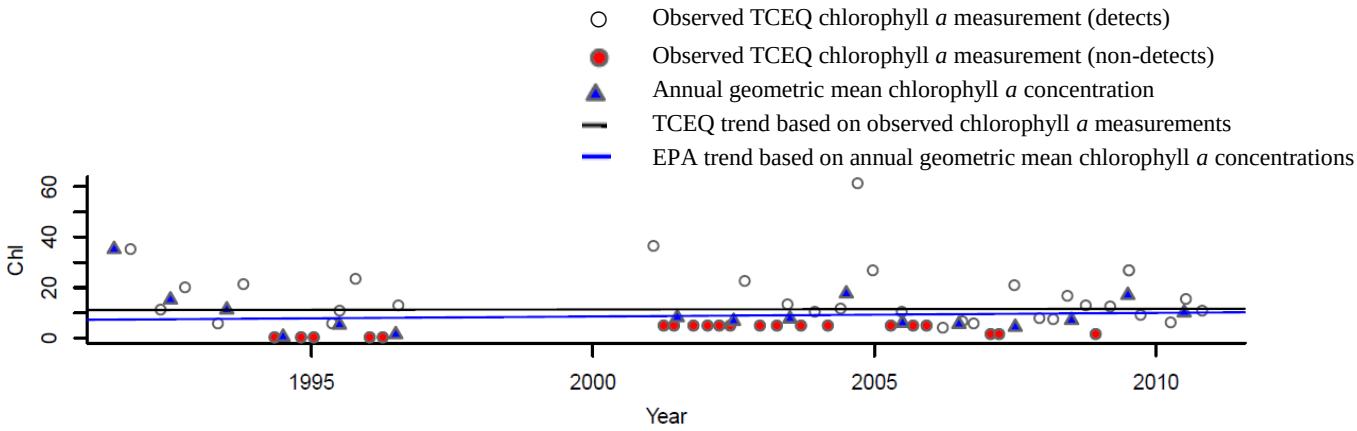
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ did not identify any statistically significant increasing trends in chlorophyll *a* concentrations for Cox Lake (see Figure 73).

Figure 73. Chlorophyll *a* Trend for Cox Lake Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Cox Lake based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 74). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Cox Lake, the magnitude of the slope of this increasing trend was relatively moderate at 0.145 µg/L chlorophyll *a*/year.

Figure 74. Chlorophyll *a* Trends for Cox Lake Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Cox Lake was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Cox Lake between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 55.24 was determined for the 2010 reporting cycle for Cox Lake. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 8.02 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Cox Lake shifted from a eutrophic classification for the 2000 reporting cycle to a hypereutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Cox Lake, the chlorophyll *a* criterion is below 30 µg/L but 7% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Cox Lake, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is not satisfied in the case of Cox Lake. Reservoir-specific data and information described above indicates a eutrophic classification for Cox Lake in the 2000 reporting cycle with a shift to a hypereutrophic classification in the 2010 reporting cycle. Reservoir-specific data and information described above indicates a relatively moderate rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.145 µg/L chlorophyll *a*/year) and an increasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. TCEQ did not identify any CWA §303(d) listings for pH or DO for Cox Lake. However, TCEQ did identify two concerns for chlorophyll *a* in Cox Lake in the 2006 and 2008 reporting cycles, as well as seven concerns for nutrients (NO3-N, OP, and TP) in the 2006 through 2010 reporting cycles that were repeating. 7% of the measurements in the underlying chlorophyll *a* dataset available for Cox Lake were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is not satisfied in the case of Cox Lake, EPA not only strongly considered the shift to a hypereutrophic classification in the 2010 reporting cycle, but also strongly considered the relatively moderate rate of chlorophyll *a* accumulation

based on EPA's trend analysis (slope = 0.145 µg/L chlorophyll *a*/year) in combination with TCEQ's identification of seven nutrient concerns that were repeating. These latter two information sources indicate both the presence of nutrients in concentrations of concern to TCEQ and a biological response in the form of a relatively moderate chlorophyll *a* accumulation rate. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 13.56 µg/L applicable to Cox Lake is not protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA disapproves this reservoir-specific chlorophyll *a* criterion.

38. <u>White River Lake, Segment 1240, Chlorophyll *a* Criterion 13.85 µg/L (Approved*)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 36 measurements collected between between May 22, 1990, and November 17, 2008. Of these 36 measurements, 3 were considered to be outliers because they had values greater than 27.375 µg/L. So, the criterion was derived using a final dataset consisting of 33 chlorophyll *a* measurements collected between between May 22, 1990, and November 17, 2008, all of which were equal to or below 25.5 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for White River Lake.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, no water quality concerns for any nutrient or nutrient enrichment-related indicators were identified for White River Lake.

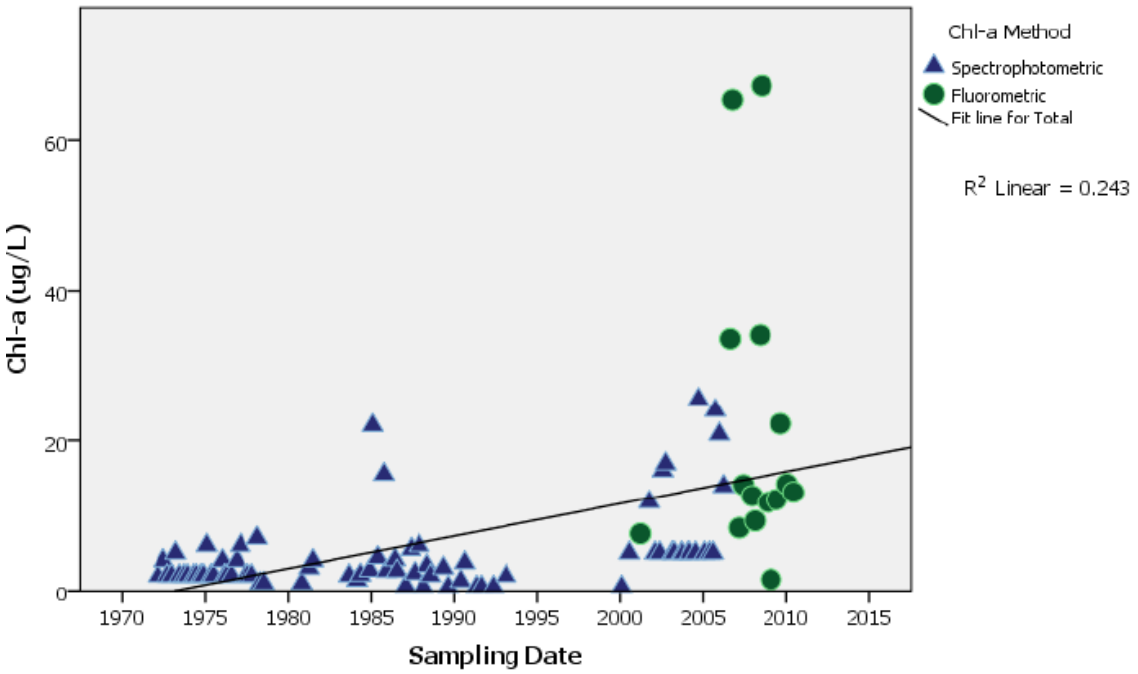
Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for White River Lake in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: White River Lake was not sampled as part of the 2007 NLA.

TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 91 chlorophyll *a* measurements collected from White River Lake between 1972 and 2010 (see Figure 75). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for White River Lake. Based upon the supporting information provided by TCEQ, a shift in methodology does appear to have occurred for this dataset in 2006 (with all data after 2006 being collected using the fluorometric method rather than the spectrophotometric method). Seventy-six chlorophyll *a* measurements were made using the spectrophotometric method, with 39 of these measurements (~51%) being reported as less than the minimum reporting limits. Fifteen measurements were made using the fluorometric method, with 1 of these measurements (~7%) being reported as less than the minimum reporting limits. When TCEQ analyzed trends for each of these datasets separately, the chlorophyll *a* data collected using the fluorometic method did not show a statistically significant increasing trend, while the chlorophyll *a* data collected using the spectrophotometric method did show a statistically significant increasing trend. In further analyzing the spectrophotometric method dataset, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) affected the statistical significance of this chlorophyll *a*

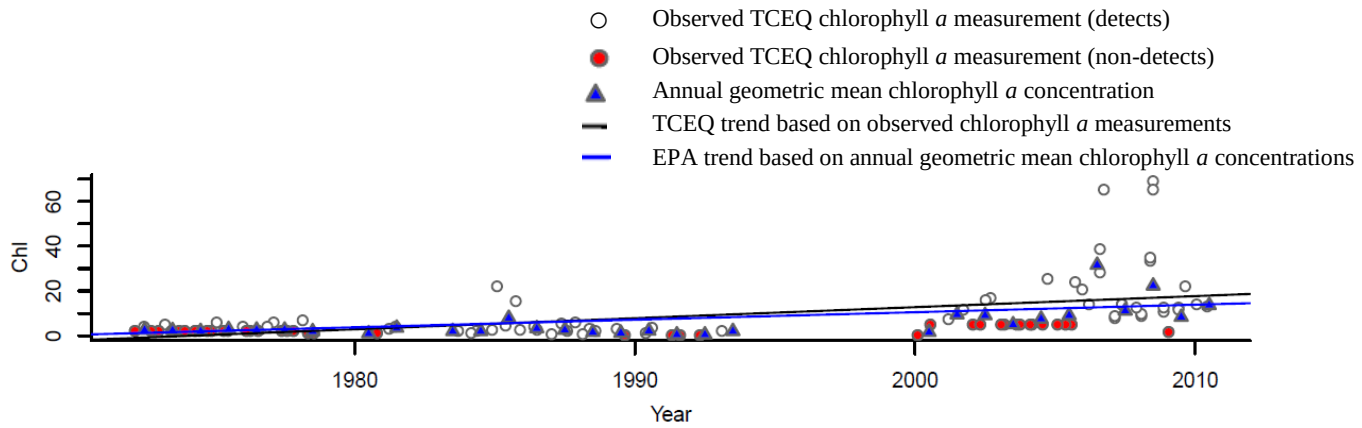
trend to such a degree that the increasing trend for White River Lake was no longer considered statistically significant.

Figure 75. Chlorophyll *a* Trend for White River Lake Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for White River Lake based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 76). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For White River Lake, the magnitude of the slope of this increasing trend was relatively high at 0.336 µg/L chlorophyll *a*/year.

Figure 76. Chlorophyll *a* Trends for White River Lake Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: White River Lake was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting

cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for White River Lake between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 52.44 was determined for the 2010 reporting cycle for White River Lake. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 18.7 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that White River Lake shifted from an oligotrophic classification for the 2000 reporting cycle to a eutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For White River Lake, the chlorophyll *a* criterion is below 30 µg/L but 2% of the chlorophyll a measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for White River Lake, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of White River Lake. Reservoir-specific data and information described above indicates an oligotrophic classification for White River Lake in the 2000 reporting cycle with a shift to a eutrophic classification in the 2010 reporting cycle. Reservoir-specific data and information described above indicates a relatively high rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.336 µg/L chlorophyll *a*/year) and an increasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. However, TCEQ did not identify any CWA §303(d) listings for pH or DO for White River Lake, nor did it identify any concerns for nutrient or nutrient-enrichment related indicators. Further, only 2% of the measurements in the underlying chlorophyll *a* dataset available for White River Lake were greater than 30 µg/L. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 13.85 µg/L applicable to White River Lake is protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

39. <u>Aquilla Reservoir, Segment 1254, Chlorophyll *a* Criterion 14.10 µg/L (Disapproved)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 64 measurements collected between between June 7, 1990, and October 28, 2008. Of these 64 measurements, 1 was considered to be an outlier because it had a value greater than 26.875 µg/L. So, the criterion was derived using a final dataset consisting of 63 chlorophyll *a* measurements collected between between June 7, 1990, and October 28, 2008, all of which were equal to or below 26.2 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for pH and DO listings in the 2000 through 2010 reporting cycles, the following 303(d) listings were identified for Aquilla Reservoir:

Year	Parameter	Assessment Unit	Assessment Unit Description
2002	DO	n/a	Aquilla Creek arm on the west
2004	DO	n/a	Aquilla Creek arm on the west
2000	DO	n/a	Entire reservoir
2002	DO	n/a	Hackberry Creek arm on the east

Year	Parameter	Assessment Unit	Assessment Unit Description
2004	DO	n/a	Hackberry Creek arm on the east
2002	DO	n/a	South end of reservoir near dam
2004	DO	n/a	South end of reservoir near dam

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Aquilla Reservoir:

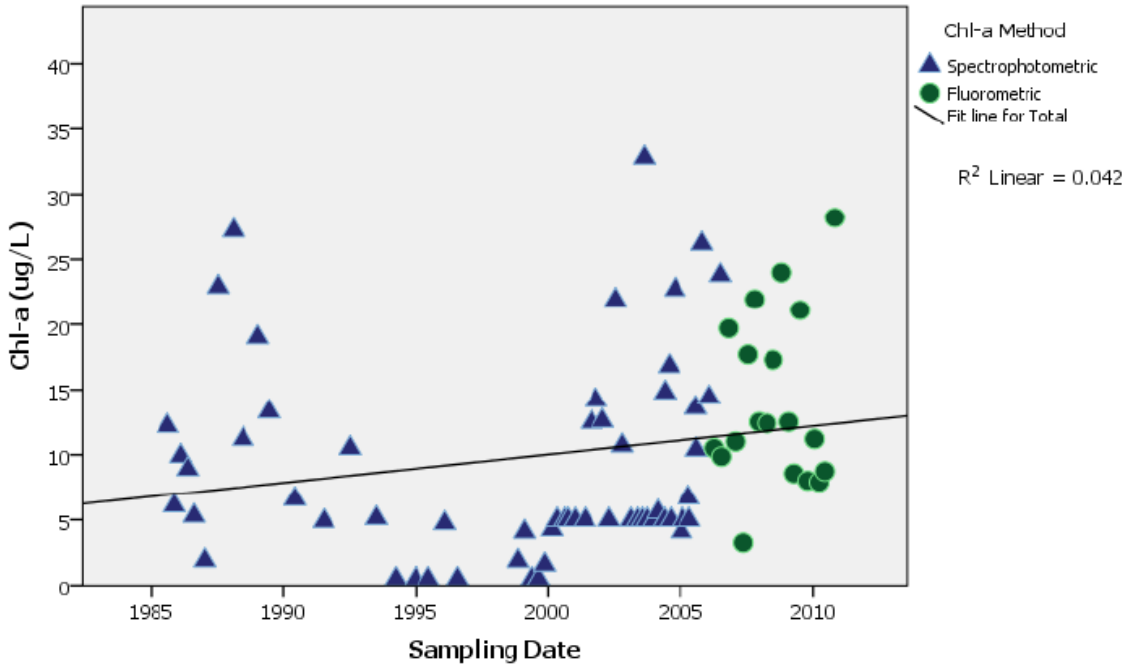
Year	Parameter	Assessment Unit	Assessment Unit Description
2006	NO3-N	1254_01	South end of reservoir near dam
2008	NO3-N	1254_01	South end of reservoir near dam
2010	NO3-N	1254_01	South end of reservoir near dam
2006	NO3-N	1254_02	Aquilla Creek arm on the west
2008	NO3-N	1254_02	Aquilla Creek arm on the west
2010	NO3-N	1254_02	Aquilla Creek arm on the west
2006	NO3-N	1254_03	Hackberry Creek arm on the east
2008	NO3-N	1254_03	Hackberry Creek arm on the east
2010	NO3-N	1254_03	Hackberry Creek arm on the east

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Aquilla Reservoir in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Aquilla Reservoir was not sampled as part of the 2007 NLA.

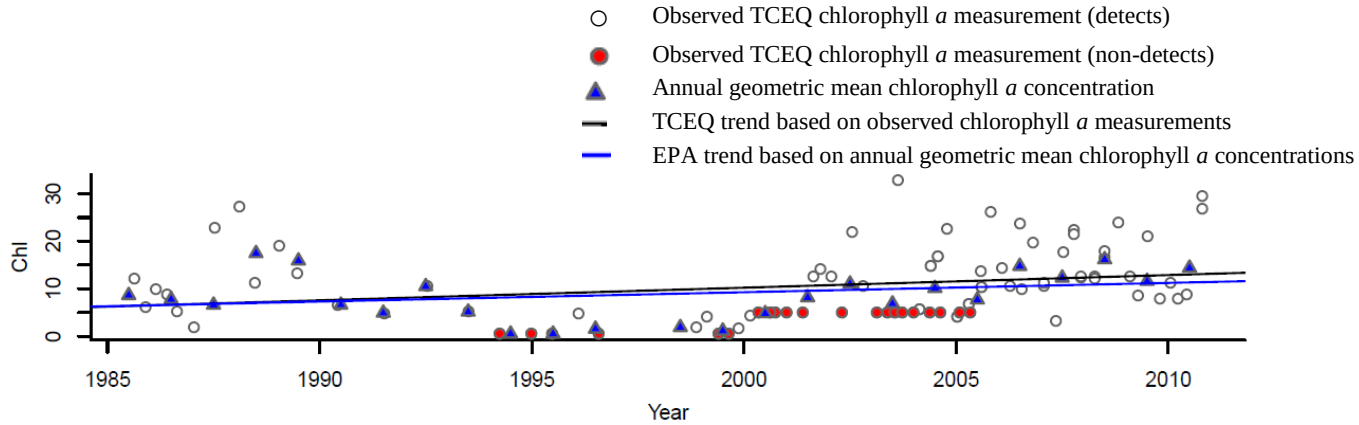
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ did not identify any statistically significant increasing trends in chlorophyll *a* concentrations for Aquilla Reservoir (see Figure 77).

Figure 77. Chlorophyll *a* Trend for Aquilla Reservoir Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Aquilla Reservoir based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 78). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Aquilla Reservoir, the magnitude of the slope of this increasing trend was relatively moderate at 0.197 µg/L chlorophyll *a*/year.

Figure 78. Chlorophyll *a* Trends for Aquilla Reservoir Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Aquilla Reservoir was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Aquilla Reservoir between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 51.64 was determined for the 2010 reporting cycle for Aquilla Reservoir. This

value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 9.68 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Aquilla Reservoir shifted from a mesotrophic classification for the 2000 reporting cycle to a eutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Aquilla Reservoir, the chlorophyll *a* criterion is below 30 µg/L but 1% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Aquilla Reservoir, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is not satisfied in the case of Aquilla Reservoir. Reservoir-specific data and information described above indicates a mesotrophic classification for Aquilla Reservoir in the 2000 reporting cycle with a shift to a eutrophic classification in the 2010 reporting cycle. Reservoir-specific data and information described above indicates a relatively moderate rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.197 µg/L chlorophyll *a*/year) and an increasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. TCEQ identified seven CWA §303(d) listings for DO in Aquilla Reservoir, with one DO listing in the 2000 reporting cycle for the entire reservoir, as well as DO listings in the 2002 and 2004 reporting cycles in each of the three assessment units for Aquilla Reservoir (i.e., the entire reservoir). Additionally, TCEQ identifed nine concerns for nutrients (NO3-N) in Aquilla Reservoir that were repeating. NO3-N was identified as a concern in the 2006 through 2010 reporting cycles in each of the three assessment units for Aquilla Reservoir (i.e., the entire reservoir). 1% of the measurements in the underlying chlorophyll *a* dataset available for Aquilla Reservoir were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is not satisfied in the case of Aquilla Reservoir, EPA strongly considered the relatively moderate rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.197 µg/L chlorophyll *a*/year) in combination with TCEQ's identification of nine nutrient concerns that were repeating. These two information sources indicate both the presence of nutrients in concentrations of concern to TCEQ and a biological response in the form of a relatively moderate chlorophyll *a* accumulation rate. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 14.10 µg/L applicable to Aquilla Reservoir is not protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA disapproves this reservoir-specific chlorophyll *a* criterion.

40. <u>Twin Buttes Reservoir, Segment 1423, Chlorophyll *a* Criterion 14.44 µg/L (Disapproved)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 35 measurements collected between between August 8, 1990, and December 10, 2008. Of these 35 measurements, 3 were considered to be outliers because they had values greater than 29.7975 µg/L. So, the criterion was derived using a final dataset consisting of 32 chlorophyll *a* measurements collected between between August 8, 1990, and December 10, 2008, all of which were equal to or below 28.2 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Twin Buttes Reservoir.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Twin Buttes Reservoir:

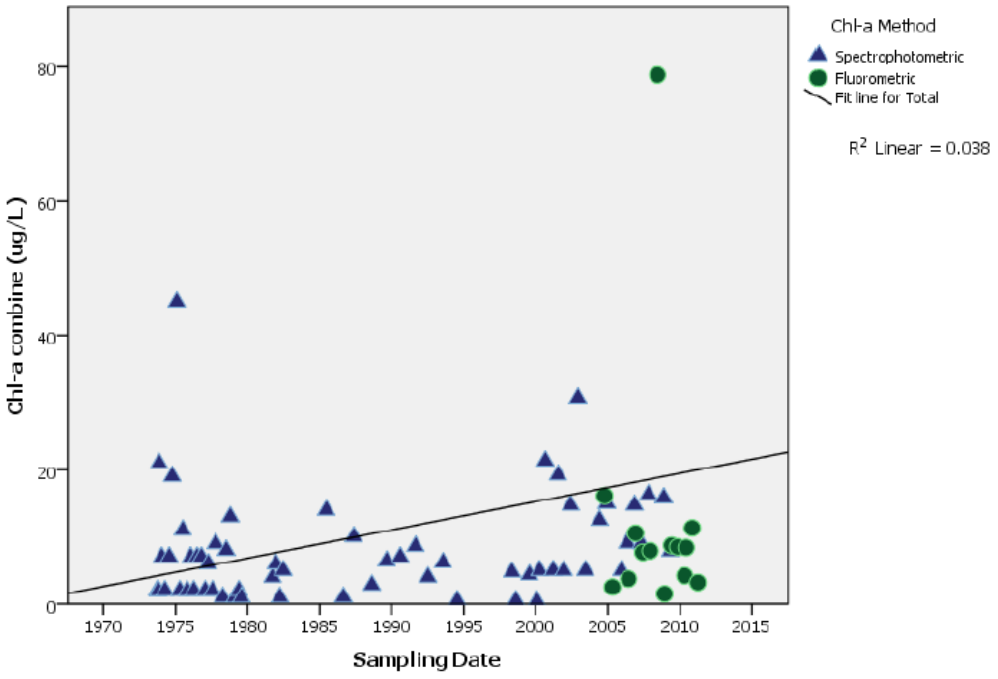
Year	Parameter	Assessment Unit	Assessment Unit Description
2006	NO3-N	1423_01	North pool
2008	NO3-N	1423_01	North pool
2006	OP	1423_01	North pool
2008	OP	1423_01	North pool
2010	OP	1423_01	North pool
2008	OP	1423_02	South pool
2010	OP	1423_02	South pool

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Twin Buttes Reservoir in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Twin Buttes Reservoir was not sampled as part of the 2007 NLA.

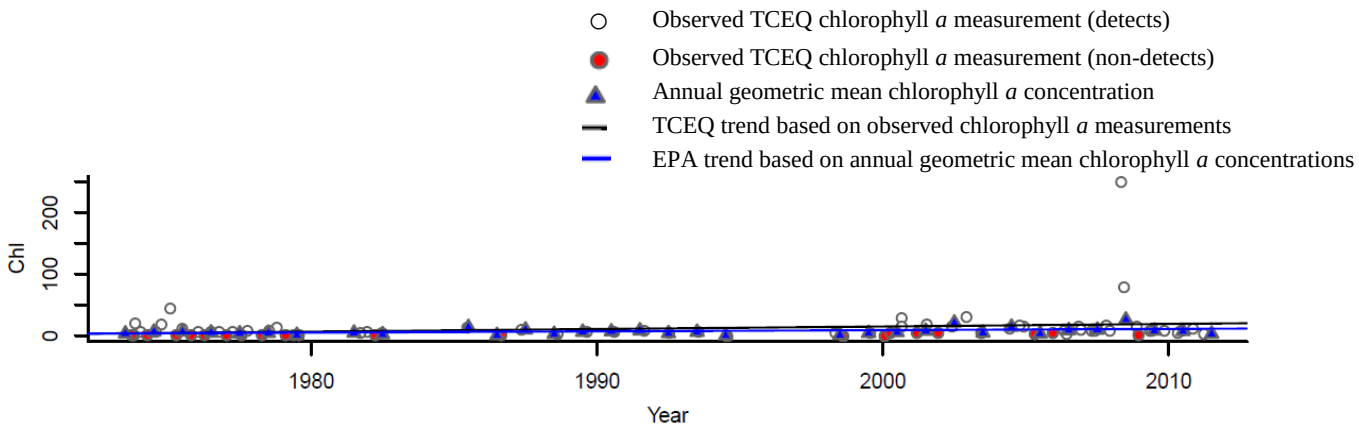
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ did not identify any statistically significant increasing trends in chlorophyll *a* concentrations for Twin Buttes Reservoir (see Figure 79).

Figure 79. Chlorophyll *a* Trend for Twin Buttes Reservoir Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Twin Buttes Reservoir based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 80). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Twin Buttes Reservoir, the magnitude of the slope of this increasing trend was relatively high at 0.201 µg/L chlorophyll *a*/year.

Figure 80. Chlorophyll *a* Trends for Twin Buttes Reservoir Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Twin Buttes Reservoir was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Twin Buttes Reservoir between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 61.76 was determined for the 2010 reporting cycle for Twin Buttes Reservoir. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 16.16 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Twin Buttes Reservoir shifted from a eutrophic classification for the 2000 reporting cycle to a hypereutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Twin Buttes Reservoir, the chlorophyll *a* criterion is below 30 µg/L but 6% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Twin Buttes Reservoir, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is not satisfied in the case of Twin Buttes Reservoir. Reservoir-specific data and information described above indicates a eutrophic classification for Twin Buttes Reservoir in the 2000 reporting cycle with a shift to a hypereutrophic classification in the 2010 reporting cycle. Reservoir-specific data and information described above indicates a relatively high rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.201 µg/L chlorophyll *a*/year) and an increasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's

review of TCEQ's trend analysis. TCEQ did not identify any CWA §303(d) listings for pH or DO for Twin Buttes Reservoir. However, TCEQ did identify seven concerns for nutrients (NO3-N and OP) in the 2006 through 2010 reporting cycles that were repeating. 6% of the measurements in the underlying chlorophyll *a* dataset available for Twin Buttes Reservoir were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is not satisfied in the case of Twin Buttes Reservoir, EPA not only strongly considered the shift to a hypereutrophic classification in the 2010 reporting cycle, but also strongly considered the relatively high rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.201 µg/L chlorophyll *a*/year) in combination with TCEQ's identification of seven nutrient concerns that were repeating. These latter two information sources indicate both the presence of nutrients in concentrations of concern to TCEQ and a biological response in the form of a relatively high chlorophyll *a* accumulation rate. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 14.44 µg/L applicable to Twin Buttes Reservoir is not protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA disapproves this reservoir-specific chlorophyll *a* criterion.

41. <u>Lake Fork Reservoir, Segment 0512, Chlorophyll *a* Criterion 14.50 µg/L (Disapproved)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 139 measurements collected between between January 9, 1990, and November 11, 2008. Of these 139 measurements, 3 were considered to be outliers because they had values greater than 27.5 µg/L. So, the criterion was derived using a final dataset consisting of 136 chlorophyll *a* measurements collected between between January 9, 1990, and November 11, 2008, all of which were equal to or below 27.2 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Lake Fork Reservoir.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Lake Fork Reservoir:

Year	Parameter	Assessment Unit	Assessment Unit Description
2008	OP	0512_03	Running Creek cove, centering on FM 2966
2010	OP	0512_03	Running Creek cove, centering on FM 2966
2008	Chl-a	0512_05	Uppermost 5120 acres of Lake Fork Creek arm
2010	Chl-a	0512_05	Uppermost 5120 acres of Lake Fork Creek arm

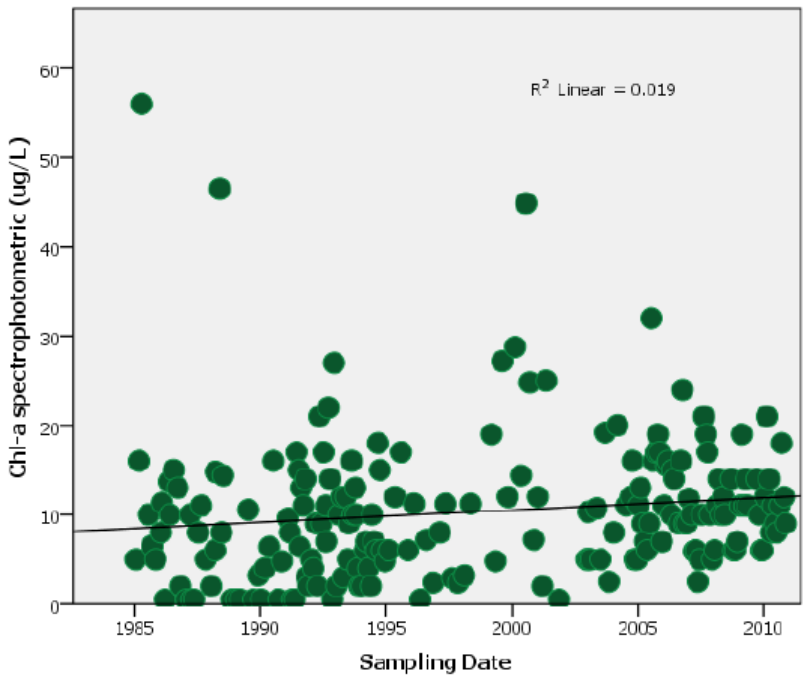
Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Lake Fork Reservoir in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Lake Fork Reservoir was not sampled as part of the 2007 NLA.

TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 196 chlorophyll *a* measurements collected from Lake Fork Reservoir between 1985 and 2010 (see Figure 81). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that

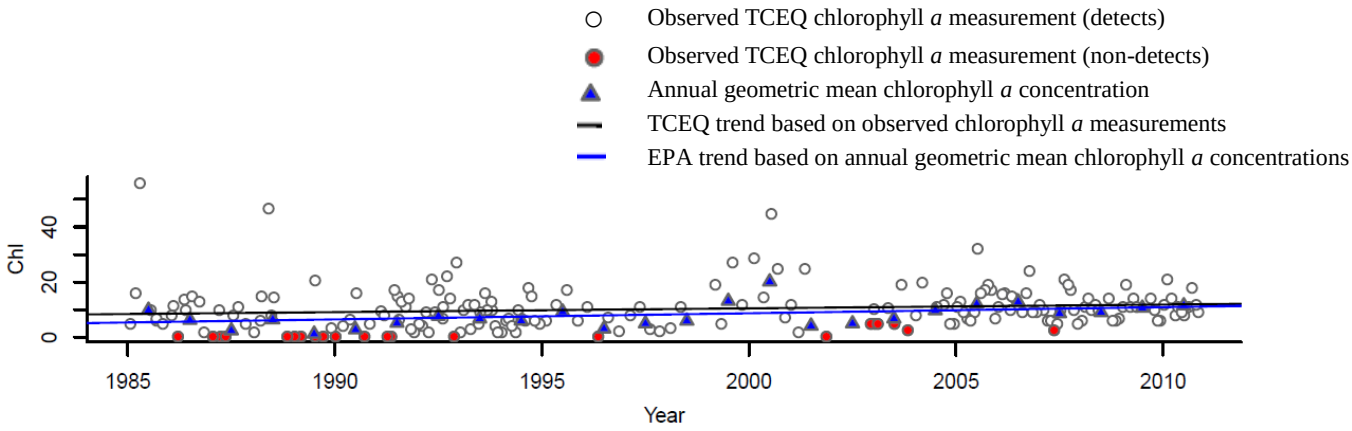
TCEQ used to conduct the trends analysis for Lake Fork Reservoir. Based upon the supporting information provided by TCEQ, all of these chlorophyll *a* measurements were determined using the same method (spectrophotometric). Twenty-two of these 196 measurements (~11%) were reported as being less than the reporting limits. In further analyzing the spectrophotometric method dataset, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) affected the statistical significance of this chlorophyll *a* trend to such a degree that the increasing trend for Lake Fork Reservoir was no longer considered statistically significant.

Figure 81. Chlorophyll *a* Trend for Lake Fork Reservoir Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Lake Fork Reservoir based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 82). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Lake Fork Reservoir, the magnitude of the slope of this increasing trend was relatively high at 0.222 µg/L chlorophyll *a*/year.

Figure 82. Chlorophyll *a* Trends for Lake Fork Reservoir Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Lake Fork Reservoir was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Lake Fork Reservoir between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 55.42 was determined for the 2010 reporting cycle for Lake Fork Reservoir. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 7.38 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Lake Fork Reservoir shifted from a eutrophic classification for the 2000 reporting cycle to a hypereutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Lake Fork Reservoir, the chlorophyll *a* criterion is below 30 µg/L but 2% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Lake Fork Reservoir, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is not satisfied in the case of Lake Fork Reservoir. Reservoir-specific data and information described above indicates a eutrophic classification for Lake Fork Reservoir in the 2000 reporting cycle with a shift to a hypereutrophic classification in the 2010 reporting cycle. Reservoir-specific data and information described above indicates a relatively high rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.222 µg/L chlorophyll *a*/year) and an increasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. TCEQ did not identify any CWA §303(d) listings for pH or DO for Lake Fork Reservoir. TCEQ did identify two concerns for chlorophyll *a* in the 2008 through 2010 reporting cycles for the upper portion of Lake Fork Creek arm. And, though not considered repeating (as previously defined in Footnote 2), TCEQ identified two nutrient concerns (OP) in the 2008 through 2010 reporting cycles in Running Creek Cove of Lake Fork Reservoir. 2% of the measurements in the underlying chlorophyll *a* dataset available for Lake Fork Reservoir were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is not satisfied in the case of Lake Fork Reservoir,

EPA strongly considered the shift to a hypereutrophic classification in the 2010 reporting cycle, along with the relatively high rate of chlorophyll a accumulation based on EPA's trend analysis (slope = 0.222 µg/L chlorophyll *a*/year). Based on the above information, EPA concludes that the chlorophyll *a* criterion of 14.50 µg/L applicable to Lake Fork Reservoir is not protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA disapproves this reservoir-specific chlorophyll *a* criterion.

42. <u>Navarro Mills Lake, Segment 0817, Chlorophyll *a* Criterion 15.07 µg/L (Approved*)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 33 measurements collected between between June 25, 1990, and August 21, 2008. Of these 33 measurements, none were considered to be outliers because none had values greater than 25.25 µg/L. So, the criterion was derived using a final dataset consisting of 33 chlorophyll *a* measurements collected between between June 25, 1990, and August 21, 2008, all of which were equal to or below 23.1 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Navarro Mills Lake.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Navarro Mills Lake:

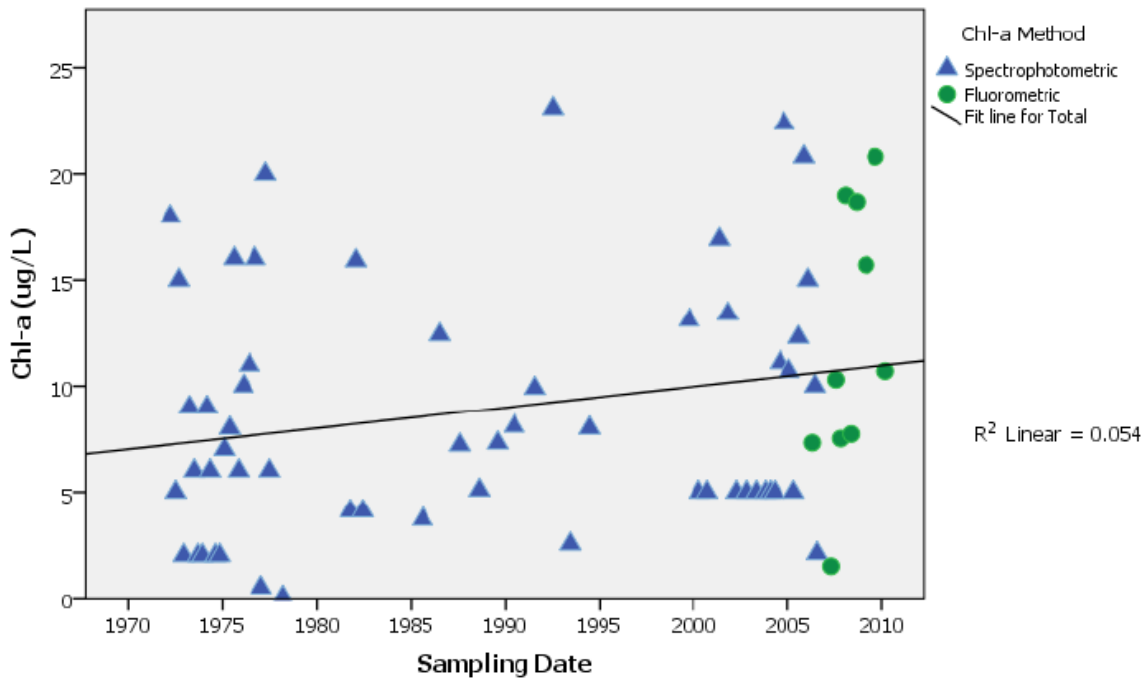
Year	Parameter	Assessment Unit	Assessment Unit Description
2006	NO3-N	0817_01	Entire reservoir
2008	NO3-N	0817_01	Entire reservoir
2010	NO3-N	0817_01	Entire reservoir

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Navarro Mills Lake in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Navarro Mills Lake was not sampled as part of the 2007 NLA.

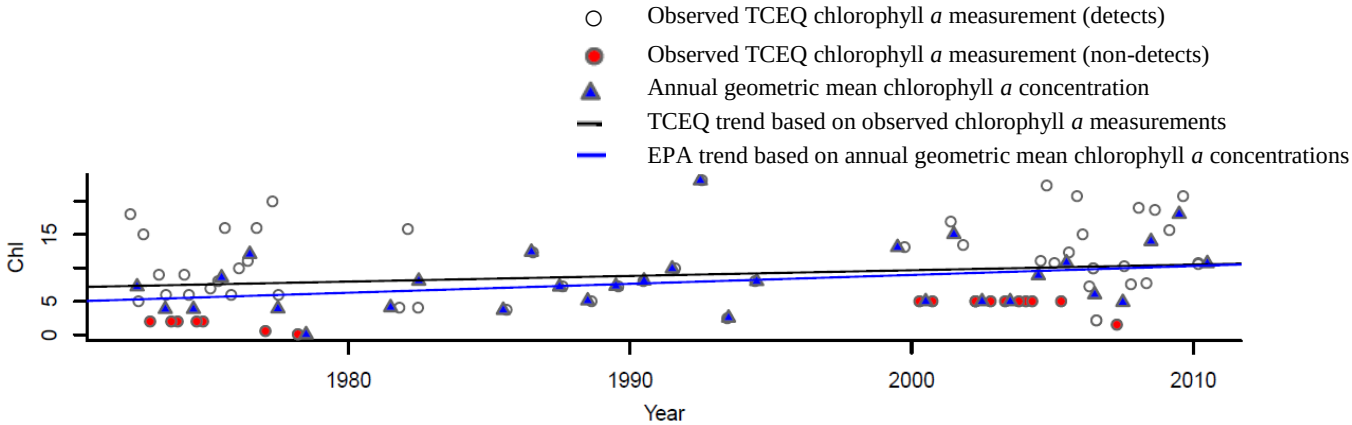
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ did not identify any statistically significant increasing trends in chlorophyll *a* concentrations for Navarro Mills Lake (see Figure 83).

Figure 83. Chlorophyll *a* Trend for Navarro Mills Lake Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Navarro Mills Lake based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 84). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Navarro Mills Lake, the magnitude of the slope of this increasing trend was relatively moderate at 0.133 µg/L chlorophyll *a*/year.

Figure 84. Chlorophyll *a* Trends for Navarro Mills Lake Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Navarro Mills Lake was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Navarro Mills Lake between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 52.96 was determined for the 2010 reporting cycle for Navarro Mills

Lake. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 1.91 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Navarro Mills Lake was eutrophic for both the 2000 and 2010 reporting cycles.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Navarro Mills Lake, the chlorophyll *a* criterion is below 30 µg/L and 0% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Navarro Mills Lake, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of Navarro Mills Lake. Reservoir-specific data and information described above indicates a eutrophic classification for Navarro Mills Lake, with a relatively moderate rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.133 µg/L chlorophyll *a*/year) and an increasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. TCEQ did not identify any CWA §303(d) listings for pH or DO for Navarro Mills Lake. TCEQ identified three nutrient (NO3-N) concerns for the same assessment unit in Navarro Mills Lake in the 2006 through 2010 reporting cycles. None of the measurements in the underlying chlorophyll *a* dataset available for Navarro Mills Lake were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is satisfied in the case of Navarro Mills Lake, EPA strongly considered the relatively moderate rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.133 µg/L chlorophyll *a*/year) and the fact that none of the measurements in the underlying chlorophyll *a* dataset available for Navarro Mills Lake were greater than 30 µg/L. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 15.07 µg/L applicable to Navarro Mills Lake is protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

43. Richland Chambers Reservoir, Segment 0836, Chlorophyll *a* Criterion 15.29 µg/L (Disapproved)

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 87 measurements collected between between February 14, 1990, and September 10, 2008. Of these 87 measurements, 3 were considered to be outliers because they had values greater than 26.6 µg/L. So, the criterion was derived using a final dataset consisting of 84 chlorophyll *a* measurements collected between between February 14, 1990, and September 10, 2008, all of which were equal to or below 24 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for pH and DO listings in the 2000 through 2010 reporting cycles, the following 303(d) listings were identified for Richland Chambers Reservoir:

Year	Parameter	Assessment Unit	Assessment Unit Description
2002	high pH	n/a	Lower portion of Chambers Creek arm
2004	high pH	n/a	Lower portion of Chambers Creek arm

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Richland Chambers Reservoir:

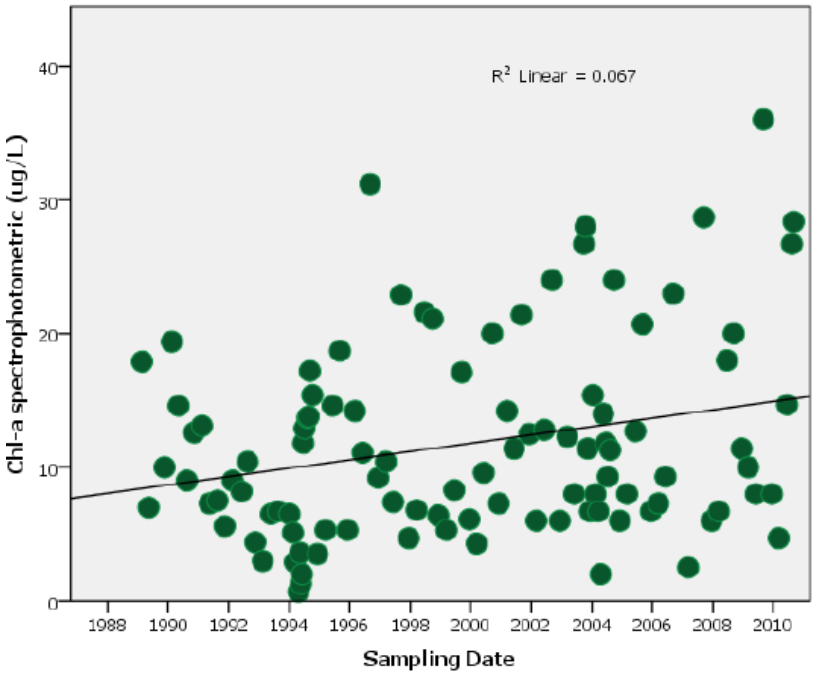
Year	Parameter	Assessment Unit	Assessment Unit Description
2010	DO	0836_01	Lowermost portion of reservoir, adjacent to dam
2006	DO	0836_03	Lower portion of Chambers Creek arm
2006	Chl-a	0836_04	Upper portion of Chambers Creek arm
2008	Chl-a	0836_04	Upper portion of Chambers Creek arm
2010	Chl-a	0836_04	Upper portion of Chambers Creek arm
2006	TP	0836_04	Upper portion of Chambers Creek arm
2008	TP	0836_04	Upper portion of Chambers Creek arm
2010	TP	0836_04	Upper portion of Chambers Creek arm
2008	Chl-a	0836_05	Lower portion of Richland Creek arm
2010	Chl-a	0836_05	Lower portion of Richland Creek arm
2006	Chl-a	0836_06	Upper portion of Richland Creek arm
2008	Chl-a	0836_06	Upper portion of Richland Creek arm

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Richland Chambers Reservoir in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Richland Chambers Reservoir was not sampled as part of the 2007 NLA.

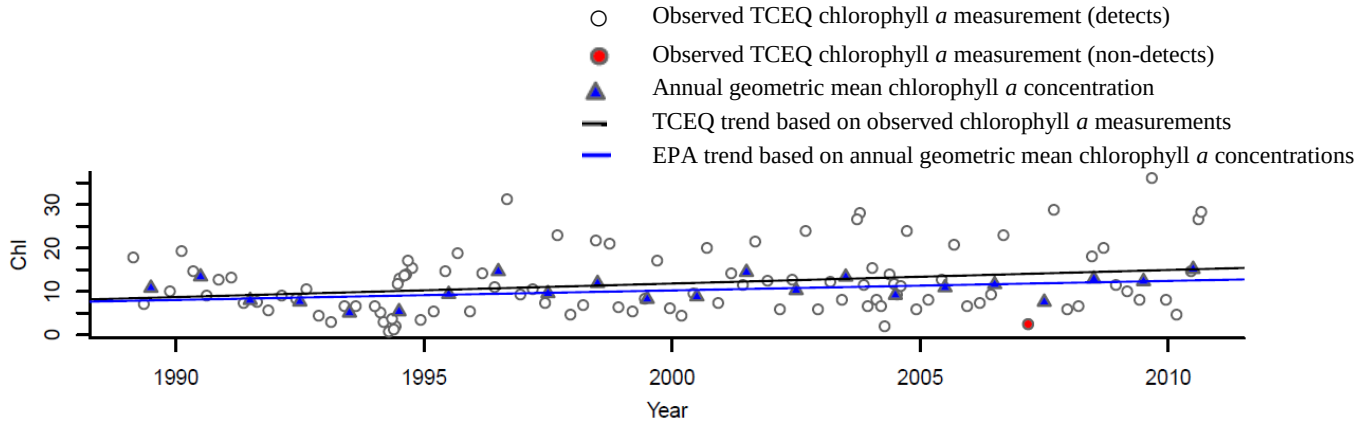
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 102 chlorophyll *a* measurements collected from Richland Chambers Reservoir between 1989 and 2010 (see Figure 85). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Richland Chambers Reservoir. Based upon the supporting information provided by TCEQ, all of these chlorophyll *a* measurements were determined using the same method (spectrophotometric). Only one of these 102 measurements (~1%) was reported as less than the reporting limit. In further analyzing the spectrophotometric method dataset, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) did not affect the statistical significance of this chlorophyll *a* trend to such a degree that the trend became statistically insignificant. Therefore, EPA believes that this increasing trend for Richland Chambers Reservoir is statistically significant.

Figure 85. Chlorophyll *a* Trend for Richland Chambers Reservoir Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Richland Chambers Reservoir based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 86). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Richland Chambers Reservoir, the magnitude of the slope of this increasing trend was relatively high at 0.220 µg/L chlorophyll *a*/year.

Figure 86. Chlorophyll *a* Trends for Richland Chambers Reservoir Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Richland Chambers Reservoir was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Richland Chambers Reservoir between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 51.26 was determined for the 2010 reporting cycle for

Richland Chambers Reservoir. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 0.38 points lower than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Richland Chambers Reservoir was eutrophic for both the 2000 and 2010 reporting cycles.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Richland Chambers Reservoir, the chlorophyll *a* criterion is below 30 µg/L but 1% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Richland Chambers Reservoir, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is not satisfied in the case of Richland Chambers Reservoir. Reservoir-specific data and information described above indicates a eutrophic classification for Richland Chambers Reservoir, with a relatively high rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.220 µg/L chlorophyll *a*/year) and a statistically significant increasing trend in chlorophyll *a* concentration based on EPA's review of TCEQ's trend analysis. TCEQ identified two CWA §303(d) listings for high pH in the lower portion of Chambers Creek Arm of Richland Chambers Reservoir in the 2002 and 2004 reporting cycles. TCEQ also identified nine concerns for DO and chlorophyll *a* in Richland Chambers Reservoir in the 2006 through 2010 reporting cycles. Additionally, TCEQ identified three concerns for nutrients (TP) in Richland Chambers Reservoir that were repeating. 1% of the measurements in the underlying chlorophyll *a* dataset available for Richland Chambers Reservoir were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is not satisfied in the case of Richland Chambers Reservoir, EPA strongly considered the relatively high rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.220 µg/L chlorophyll *a*/year) in combination with TCEQ's identification of three nutrient concerns that were repeating. These two information sources indicate both the presence of nutrients in concentrations of concern to TCEQ and a biological response in the form of a relatively high chlorophyll *a* accumulation rate. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 15.29 µg/L applicable to Richland Chambers Reservoir is not protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA disapproves this reservoir-specific chlorophyll *a* criterion.

44. <u>Lake Colorado City, Segment 1412, Chlorophyll *a* Criterion 15.60 µg/L (Disapproved)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 55 measurements collected between between April 24, 1972, and July 31, 2003. Of these 55 measurements, 2 were considered to be outliers because they had values greater than 29.25 µg/L. So, the criterion was derived using a final dataset consisting of 53 chlorophyll *a* measurements collected between between April 24, 1972, and July 31, 2003, all of which were equal to or below 26.4 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Lake Colorado City.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles,

the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Lake Colorado City:

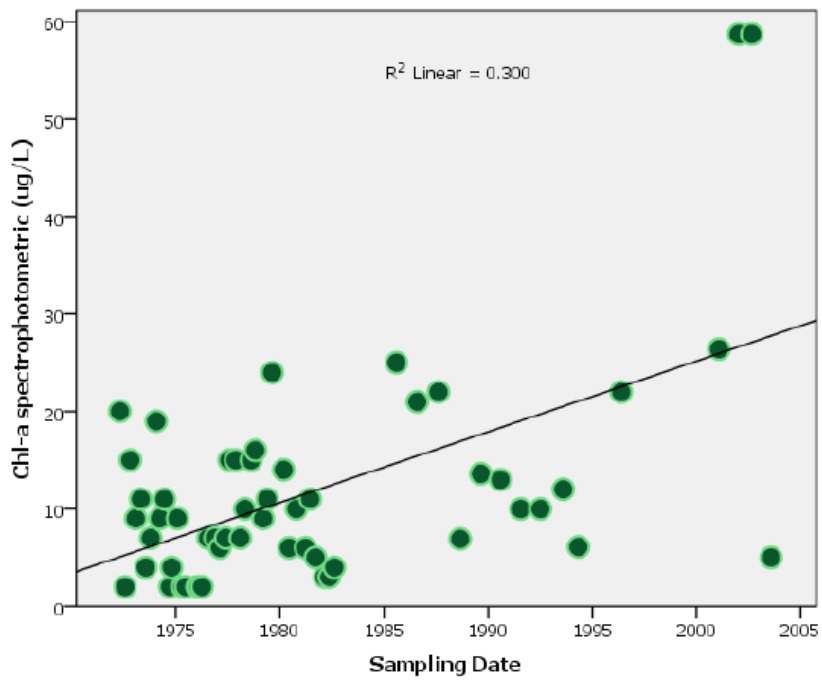
Year	Parameter	Assessment Unit	Assessment Unit Description
2006	Chl-a	1412A_01	Entire water body
2008	Chl-a	1412A_01	Entire water body
2010	Chl-a	1412A_01	Entire water body
2006	HAB/GA	1412A_01	Entire water body
2008	HAB/GA	1412A_01	Entire water body
2010	HAB/GA	1412A_01	Entire water body

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Lake Colorado City in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Lake Colorado City was not sampled as part of the 2007 NLA.

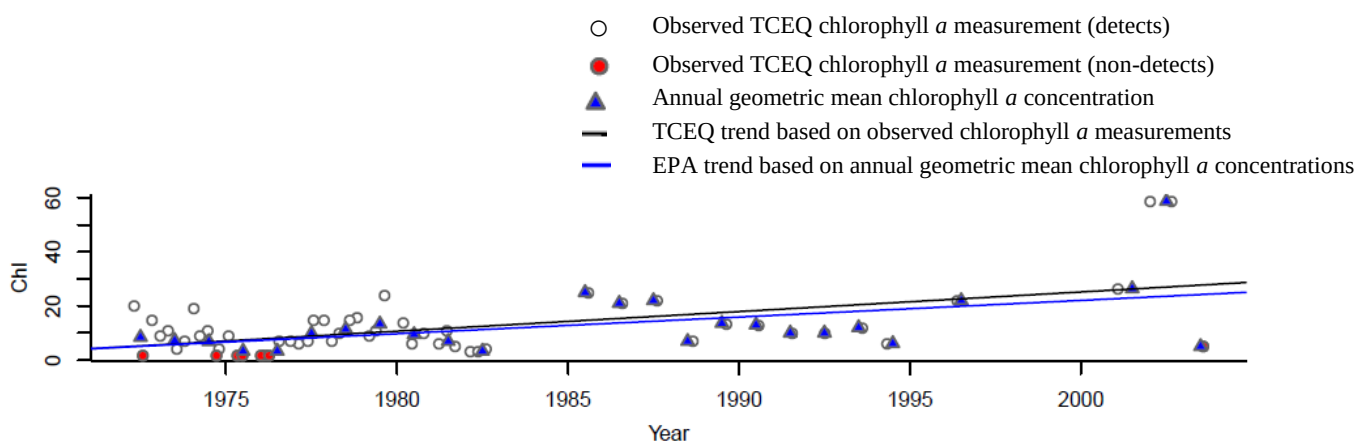
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 55 chlorophyll *a* measurements collected from Lake Colorado City between 1972 and 2003 (see Figure 87). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Lake Colorado City. Based upon the supporting information provided by TCEQ, all of these chlorophyll *a* measurements were determined using the same method (spectrophotometric). Eight of these 55 measurements (~15%) were reported as being less than the reporting limits. In further analyzing the spectrophotometric method dataset, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) did not affect the statistical significance of this chlorophyll *a* trend to such a degree that the trend became statistically insignificant. Therefore, EPA believes that this increasing trend for Lake Colorado City is statistically significant.

Figure 87. Chlorophyll *a* Trend for Lake Colorado City Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Lake Colorado City based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 88). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Lake Colorado City, the magnitude of the slope of this increasing trend was very high, relatively speaking, at 0.616 µg/L chlorophyll *a*/year.

Figure 88. Chlorophyll *a* Trends for Lake Colorado City Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Lake Colorado City was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Lake Colorado City between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 66.08 was determined for the 2010 reporting cycle for Lake Colorado

City. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 11.46 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Lake Colorado City shifted from a eutrophic classification for the 2000 reporting cycle to a hypereutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Lake Colorado City, the chlorophyll *a* criterion is below 30 µg/L but 4% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Lake Colorado City, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is not satisfied in the case of Lake Colorado City. Reservoir-specific data and information described above indicates a eutrophic classification for Lake Colorado City in the 2000 reporting cycle with a shift to a hypereutrophic classification in the 2010 reporting cycle. Reservoir-specific data and information described above indicates a very high rate of chlorophyll *a* accumulation, relatively speaking, based on EPA's trend analysis (slope = 0.616 µg/L chlorophyll *a*/year) and a statistically significant increasing trend in chlorophyll *a* concentration based on EPA's review of TCEQ's trend analysis. TCEQ did not identify any CWA §303(d) listings for pH or DO for Lake Colorado City. While TCEQ did not identify any nutrient concerns in Lake Colorado City, TCEQ did identify three concerns for chlorophyll *a* and three concerns for HAB/GA in Lake Colorado City in the 2006 through 2010 reporting cycles. 4% of the measurements in the underlying chlorophyll *a* dataset available for Lake Colorado City were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is not satisfied in the case of Lake Colorado City, EPA strongly considered the shift to a hypereutrophic classification in the 2010 reporting cycle, along with the very high rate of chlorophyll a accumulation, relatively speaking, based on EPA's trend analysis (slope = 0.616 µg/L chlorophyll *a*/year) and the three HAB/GA concerns noted above. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 15.60 µg/L applicable to Lake Colorado City is not protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA disapproves this reservoir-specific chlorophyll *a* criterion.

45. <u>Millers Creek Reservoir, Segment 1208, Chlorophyll *a* Criterion 15.65 µg/L (Disapproved)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 41 measurements collected between between May 23, 1979, and August 19, 1996. Of these 41 measurements, 5 were considered to be outliers because they had values greater than 31.7 µg/L. So, the criterion was derived using a final dataset consisting of 36 chlorophyll *a* measurements collected between between May 23, 1979, and August 19, 1996, all of which were equal to or below 26 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Millers Creek Reservoir.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles,

the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Millers Creek Reservoir:

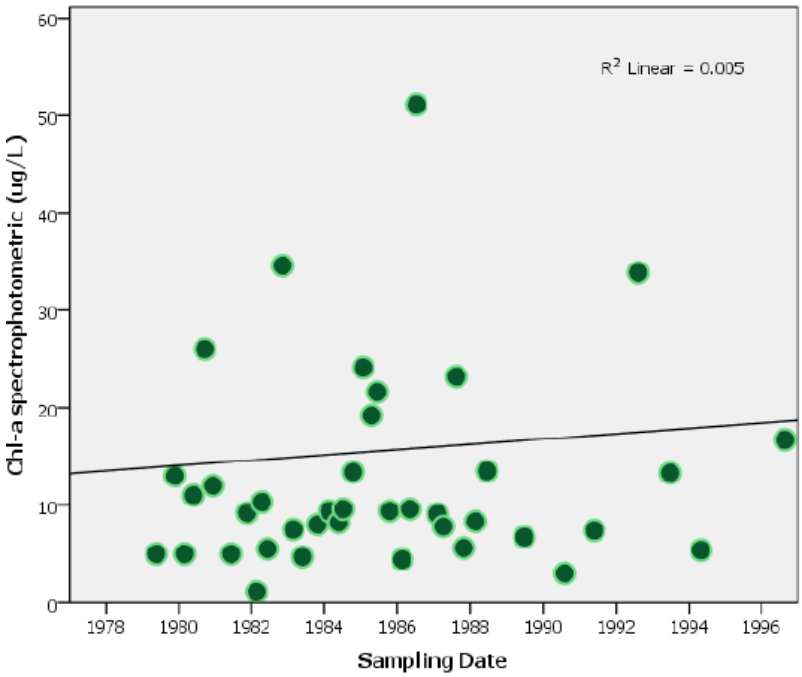
Year	Parameter	Assessment Unit	Assessment Unit Description
2006	DO	1208A_01	Entire water body
2008	DO	1208A_01	Entire water body
2010	DO	1208A_01	Entire water body

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Millers Creek Reservoir in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Millers Creek Reservoir was sampled two times as part of the 2007 NLA. During the first sampling event, the chlorophyll *a* concentration measured was 22.25 µg/L, indicating a moderate risk of exposure based on the chlorophyll *a* thresholds used in the NLA study. The microcystin concentration during the first sampling event was below the reporting limit of 0.1 µg/L, indicating a low risk of exposure based on the microcystin thresholds used in the NLA study. The cyanobacteria cell count during the first sampling event was less than 20,000 cells per milliliter, indicating a low risk of exposure based on the cyanobacteria thresholds used in the NLA study. During the second sampling event, the chlorophyll *a* concentration measured was 5.83 µg/L, indicating a low risk of exposure based on the chlorophyll *a* thresholds used in the NLA study. The microcystin concentration during the second sampling event was below the reporting limit of 0.1 µg/L, indicating a low risk of exposure based on the microcystin thresholds used in the NLA study. The cyanobacteria cell count during the second sampling event was greater than 100,000 cells per milliliter, indicating a high risk of exposure based on the cyanobacteria thresholds used in the NLA study.

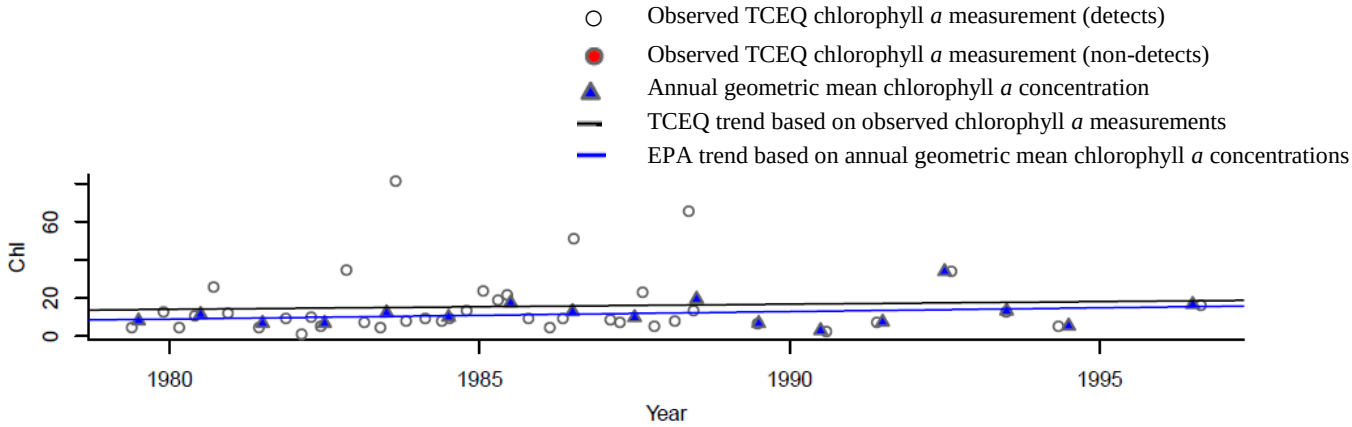
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ did not identify any statistically significant increasing trends in chlorophyll *a* concentrations for Millers Creek Reservoir (see Figure 89).

Figure 89. Chlorophyll *a* Trend for Millers Creek Reservoir Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Millers Creek Reservoir based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 90). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Millers Creek Reservoir, the magnitude of the slope of this increasing trend was relatively high at 0.394 µg/L chlorophyll *a*/year.

Figure 90. Chlorophyll *a* Trends for Millers Creek Reservoir Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Millers Creek Reservoir was not included in TCEQ's report titled *Trophic Classification of Texas Reservoirs*.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix

and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Millers Creek Reservoir, the chlorophyll *a* criterion is below 30 µg/L but 12% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Millers Creek Reservoir, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is not satisfied in the case of Millers Creek Reservoir. Trophic state classification information was not available for Millers Creek Reservoir. Reservoir-specific data and information described above indicates a relatively high rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.394 µg/L chlorophyll *a*/year) and an increasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. TCEQ did not identify any CWA §303(d) listings for pH or DO for Millers Creek Reservoir. While TCEQ did not identify any nutrient concerns in Millers Creek Reservoir, TCEQ did identify three concerns for DO in Millers Creek Reservoir in the 2006 through 2010 reporting cycles. Data from the first sampling event as part of the 2007 NLA indicated a moderate risk of exposure based on chlorophyll *a* thresholds and a low risk of exposure based on microcystin and cyanobacteria thresholds. Data from the second sampling event as part of the 2007 NLA indicated a low risk of exposure based on chlorophyll *a* and microcystin thresholds and a high risk of exposure based on cyanobacteria thresholds. Further, 12% of the measurements in the underlying chlorophyll *a* dataset available for Millers Creek Reservoir were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is not satisfied in the case of Millers Creek Reservoir, EPA strongly considered this last information source. With 12% of the measurements in the underlying chlorophyll *a* dataset available for Millers Creek Reservoir being greater than 30 µg/L, EPA is concerned that the chlorophyll *a* criterion (which is derived and expressed as a long-term central tendency), is not likely to protect designated uses from the effects of high instantaneous chlorophyll *a* concentrations (such as nuisance blooms, toxic cyanobacteria and toxin production, taste and odor compound production, and disinfection byproduct production). Based on the above information, EPA concludes that the chlorophyll *a* criterion of 15.65 µg/L applicable to Millers Creek Reservoir is not protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA disapproves this reservoir-specific chlorophyll *a* criterion.

46. <u>Lake Stamford, Segment 1235, Chlorophyll *a* Criterion 16.85 µg/L (Approved*)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 74 measurements collected between between March 6, 1974, and June 12, 2008. Of these 74 measurements, 1 was considered to be an outlier because it had a value greater than 32.1625 µg/L. So, the criterion was derived using a final dataset consisting of 73 chlorophyll *a* measurements collected between between March 6, 1974, and June 12, 2008, all of which were equal to or below 30 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Lake Stamford.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Lake Stamford:

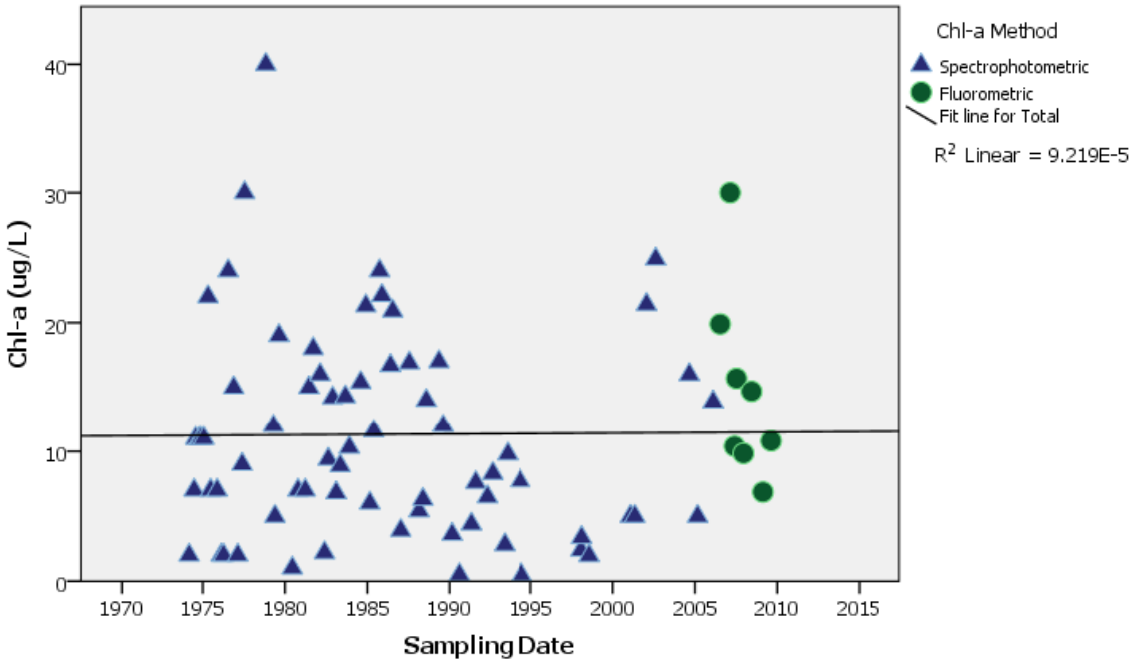
Year	Parameter	Assessment Unit	Assessment Unit Description
2008	DO	1235_01	Entire segment

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Lake Stamford in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Lake Stamford was not sampled as part of the 2007 NLA.

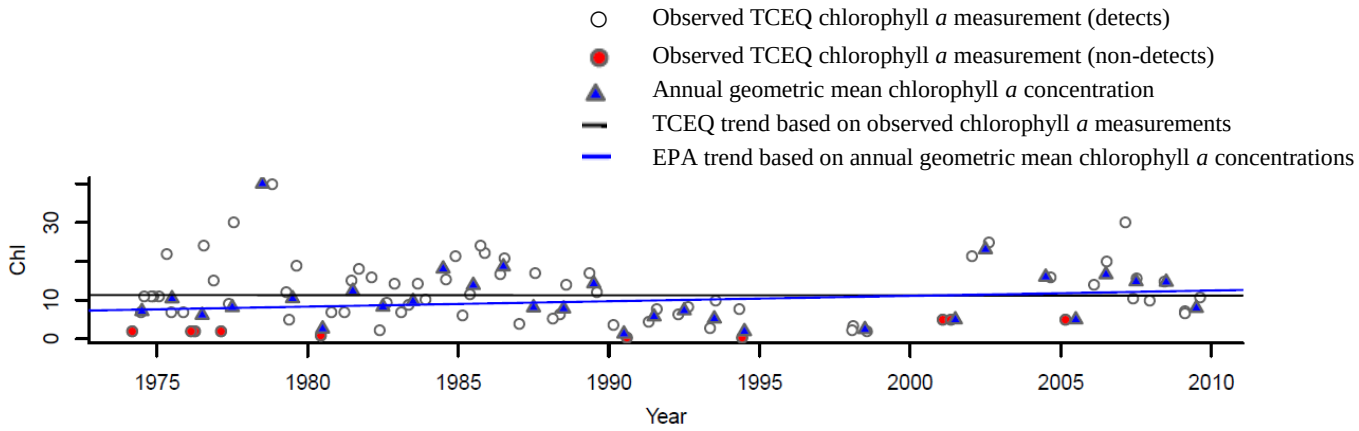
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ did not identify any statistically significant increasing trends in chlorophyll *a* concentrations for Lake Stamford (see Figure 91).

Figure 91. Chlorophyll *a* Trend for Lake Stamford Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Lake Stamford based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 92). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Lake Stamford, the magnitude of the slope of this increasing trend was relatively moderate at 0.138 µg/L chlorophyll *a*/year.

Figure 92. Chlorophyll *a* Trends for Lake Stamford Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Lake Stamford was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Lake Stamford between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 55.78 was determined for the 2010 reporting cycle for Lake Stamford. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 11.64 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Lake Stamford shifted from a mesotrophic classification for the 2000 reporting cycle to a hypereutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Lake Stamford, the chlorophyll *a* criterion is below 30 µg/L but 1% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Lake Stamford, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of Lake Stamford. Reservoir-specific data and information described above indicates a mesotrophic classification for Lake Stamford in the 2000 reporting cycle with a shift to a hypereutrophic classification in the 2010 reporting cycle. Reservoir-specific data and information described above indicates a relatively moderate rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.138 µg/L chlorophyll *a*/year) and an increasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. Additionally, TCEQ did not identify any CWA §303(d) listings for pH or DO for Lake Stamford. While TCEQ did identify one concern for DO in Lake Stamford in the 2008 reporting cycle, TCEQ did not identify concerns for any other nutrient-enrichment related indicators or any nutrient indicators. Further, only 1% of the measurements in the underlying chlorophyll *a* dataset available for Lake Stamford were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is satisfied in the case of Lake Stamford, EPA strongly considered the fact that the Carlson's chlorophyll *a* TSI value of 55.78 determined for the 2010 reporting cycle is only 0.78 points above the

eutrophic-hypereutrophic classification boundary identified in TCEQ's trophic classification report (i.e., chlorophyll *a* TSI >55 is considered hypereutrophic), as well as the relatively moderate rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.138 µg/L chlorophyll *a*/year), and the lack of 303(d) listings and nutrient concerns noted above. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 16.85 µg/L applicable to Lake Stamford is protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

47. <u>Lake Nasworthy, Segment 1422, Chlorophyll *a* Criterion 16.91 µg/L (Approved*)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 64 measurements collected between between July 31, 1990, and November 18, 2008. Of these 64 measurements, 1 was considered to be an outlier because it had a value greater than 35 µg/L. However, TCEQ also excluded 1 other measurement with a high value of 32 µg/L. So, the criterion was derived using a final dataset consisting of 62 chlorophyll *a* measurements collected between between July 31, 1990, and November 18, 2008, all of which were equal to or below 24.2 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Lake Nasworthy.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Lake Nasworthy:

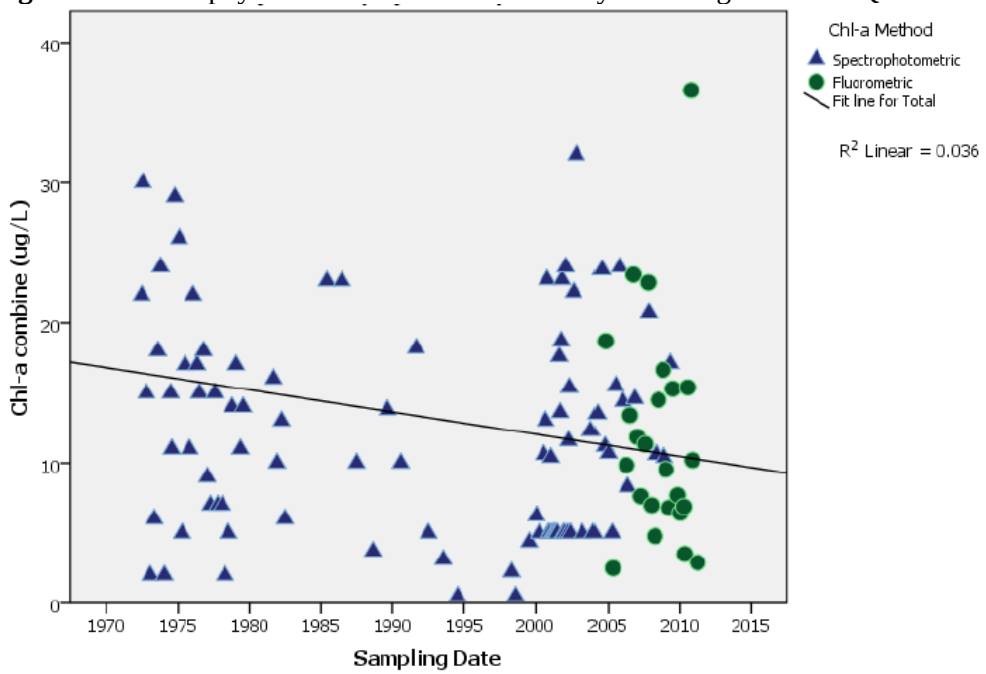
Year	Parameter	Assessment Unit	Assessment Unit Description
2010	OP	1422_02	Upper half of lake

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Lake Nasworthy in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Lake Nasworthy was not sampled as part of the 2007 NLA.

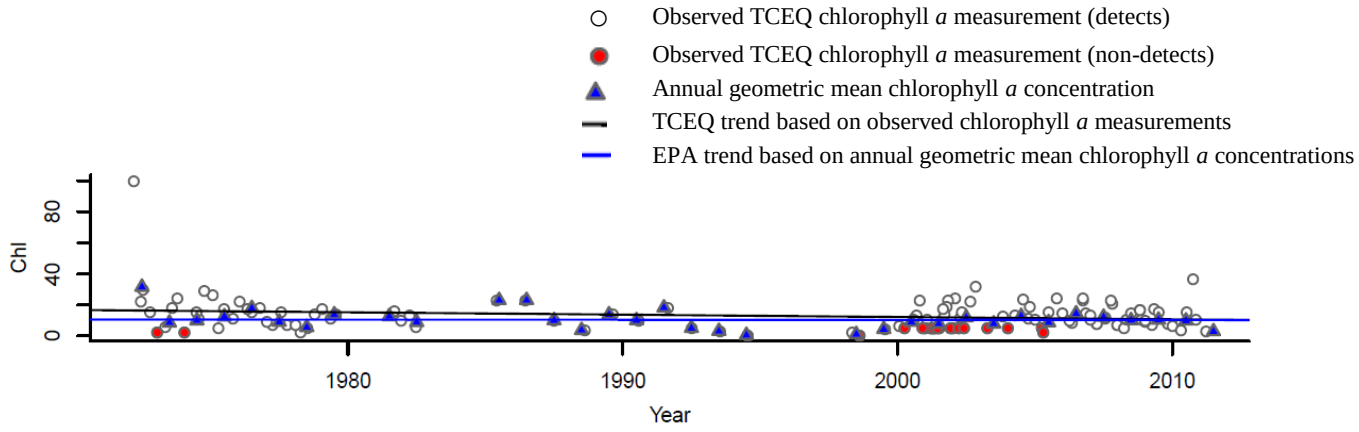
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ did not identify any statistically significant increasing trends in chlorophyll *a* concentrations for Lake Nasworthy (see Figure 93).

Figure 93. Chlorophyll *a* Trend for Lake Nasworthy Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Lake Nasworthy based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 94). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Lake Nasworthy, the trend was decreasing with a slope magnitude of -0.008 µg/L chlorophyll *a*/year.

Figure 94. Chlorophyll *a* Trends for Lake Nasworthy Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Lake Nasworthy was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Lake Nasworthy between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 54.74 was determined for the 2010 reporting cycle for Lake Nasworthy. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality

monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 8.24 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Lake Nasworthy was eutrophic for both the 2000 and 2010 reporting cycles.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Lake Nasworthy, the chlorophyll *a* criterion is below 30 µg/L but 2% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Lake Nasworthy, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of Lake Nasworthy. Reservoir-specific data and information described above indicates a eutrophic classification for Lake Nasworthy, with a decreasing rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = -0.008 µg/L chlorophyll *a*/year) and a statistically significant decreasing trend in chlorophyll *a* concentration based on EPA's review of TCEQ's trend analysis. Additionally, TCEQ did not identify any CWA §303(d) listings for pH or DO for Lake Nasworthy. While TCEQ did identify one concern for nutrients (OP) in Lake Nasworthy in the 2010 reporting cycle, this concern was not repeating. Further, only 2% of the measurements in the underlying chlorophyll *a* dataset available for Lake Nasworthy were greater than 30 µg/L. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 16.91 µg/L applicable to Lake Nasworthy is protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

48. <u>Lake Corpus Christi, Segment 2103, Chlorophyll *a* Criterion 17.17 µg/L (Disapproved)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 44 measurements collected between between April 24, 1990, and November 5, 2008. Of these 44 measurements, 1 was considered to be an outlier because it had a value greater than 34.84 µg/L. So, the criterion was derived using a final dataset consisting of 43 chlorophyll *a* measurements collected between between April 24, 1990, and November 5, 2008, all of which were equal to or below 33 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Lake Corpus Christi.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Lake Corpus Christi:

Year	Parameter	Assessment Unit	Assessment Unit Description
2006	OP	2103_01	Mid-lake near dam
2008	OP	2103_01	Mid-lake near dam
2010	OP	2103_01	Mid-lake near dam
2006	TP	2103_01	Mid-lake near dam
2008	TP	2103_01	Mid-lake near dam

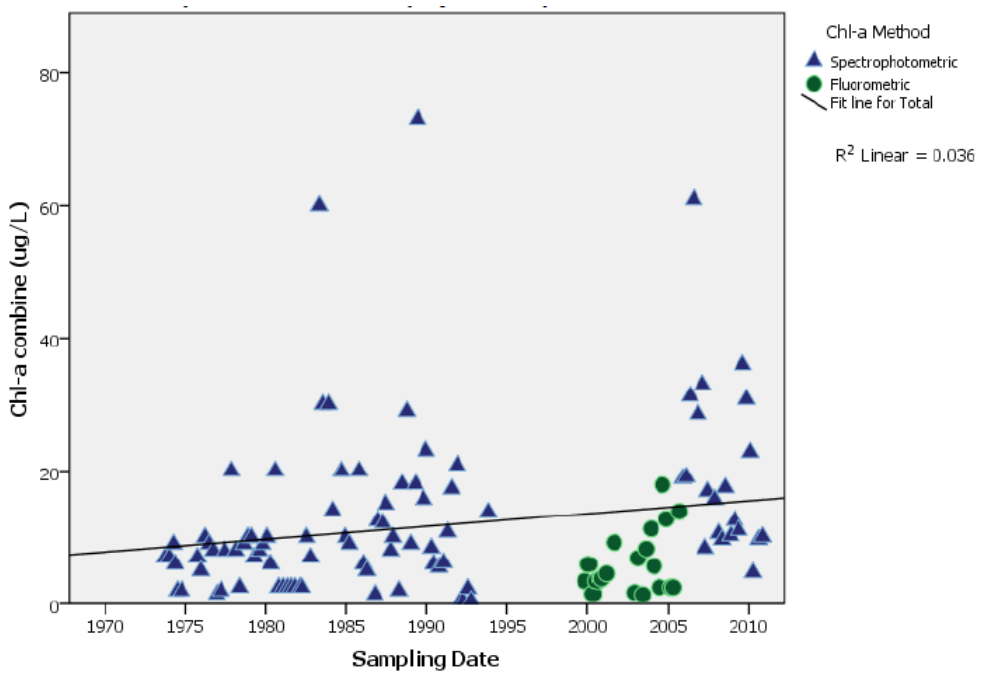
Year	Parameter	Assessment Unit	Assessment Unit Description
2008	Chl-a	2103_02	Area approx. 4 mi. SE of FM 3162 and FM 534 intersection near western shore
2010	Chl-a	2103_02	Area approx. 4 mi. SE of FM 3162 and FM 534 intersection near western shore
2006	DO	2103_04	Upper portion of lake on opposite shore from Hideaway Hill
2010	OP	2103_04	Upper portion of lake on opposite shore from Hideaway Hill
2008	Chl-a	2103_06	Remainder of lake
2010	Chl-a	2103_06	Uppermost riverine part of reservoir upstream of FM 534 to upper end of segment to just upstream of US Highway 59
2006	OP	2103_06	Remainder of lake
2008	OP	2103_06	Remainder of lake
2010	OP	2103_06	Uppermost riverine part of reservoir upstream of FM 534 to upper end of segment to just upstream of US Highway 59
2010	TP	2103_06	Uppermost riverine part of reservoir upstream of FM 534 to upper end of segment to just upstream of US Highway 59

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Lake Corpus Christi in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Lake Corpus Christi was not sampled as part of the 2007 NLA.

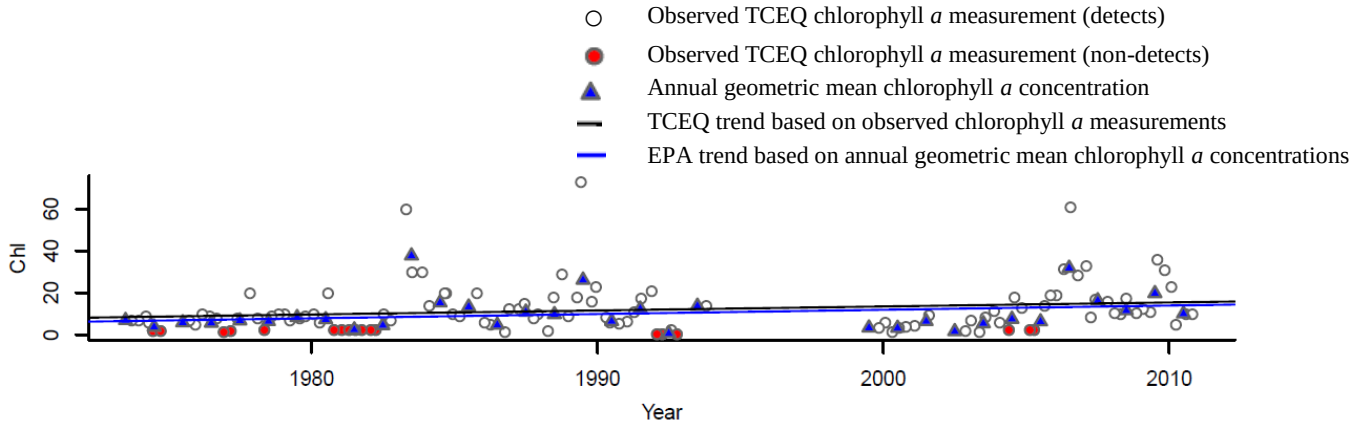
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 112 chlorophyll *a* measurements collected from Lake Corpus Christi between 1973 and 2010 (see Figure 95). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Lake Corpus Christi. Based upon the supporting information provided by TCEQ, a shift in methodology does appear to have occurred for this dataset. Data between 1999 and 2005 were collected in using the fluorometric method, while the remaining data were collected using the spectrophotometric method. Ninety-three chlorophyll *a* measurements were made using the spectrophotometric method, with 15 of these measurements (~16%) being reported as less than the minimum reporting limits. Nineteen measurements were made using the fluorometric method, with 3 of these measurements (~16%) being reported as less than the minimum reporting limits. When TCEQ analyzed trends for each of these datasets separately, the chlorophyll *a* data collected using the fluorometic method did not show a statistically significant increasing trend, while the chlorophyll *a* data collected using the spectrophotometric method did show a statistically significant increasing trend. In further analyzing the spectrophotometric method dataset, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) did not affect the statistical significance of this chlorophyll *a* trend to such a degree that the trend became statistically insignificant. Therefore, EPA believes that this increasing trend for Lake Corpus Christi is statistically significant.

Figure 95. Chlorophyll *a* Trend for Lake Corpus Christi Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Lake Corpus Christi based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 96). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Lake Corpus Christi, the magnitude of the slope of this increasing trend was relatively high at 0.203 µg/L chlorophyll *a*/year.

Figure 96. Chlorophyll *a* Trends for Lake Corpus Christi Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Lake Corpus Christi was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Lake Corpus Christi between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 60.74 was determined for the 2010 reporting cycle for Lake Corpus

Christi. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 10.97 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Lake Corpus Christi shifted from a eutrophic classification for the 2000 reporting cycle to a hypereutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Lake Corpus Christi, the chlorophyll *a* criterion is below 30 µg/L but 5% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Lake Corpus Christi, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is not satisfied in the case of Lake Corpus Christi. Reservoir-specific data and information described above indicates a eutrophic classification for Lake Corpus Christi in the 2000 reporting cycle with a shift to a hypereutrophic classification in the 2010 reporting cycle. Reservoir-specific data and information described above indicates a relatively high rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.203 µg/L chlorophyll *a*/year) and a statistically significant increasing trend in chlorophyll *a* concentration based on EPA's review of TCEQ's trend analysis. TCEQ did not identify any CWA §303(d) listings for pH or DO for Lake Corpus Christi. However, TCEQ did identify five concerns for chlorophyll *a* and DO in Lake Corpus Christi in the 2006 through 2010 reporting cycles, as well as ten concerns for nutrients (TP and OP) in the 2006 through 2010 reporting cycles that were repeating. 5% of the measurements in the underlying chlorophyll *a* dataset available for Lake Corpus Christi were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is not satisfied in the case of Lake Corpus Christi, EPA not only strongly considered the shift to a hypereutrophic classification in the 2010 reporting cycle, but also strongly considered the relatively high rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.203 µg/L chlorophyll *a*/year) in combination with TCEQ's identification of ten nutrient concerns that were repeating. These latter two information sources indicate both the presence of nutrients in concentrations of concern to TCEQ and a biological response in the form of a relatively high chlorophyll *a* accumulation rate. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 17.17 µg/L applicable to Lake Corpus Christi is not protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA disapproves this reservoir-specific chlorophyll *a* criterion.

49. <u>Lake Cypress Springs, Segment 0405, Chlorophyll *a* Criterion 17.54 µg/L (Approved)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 41 measurements collected between between July 24, 1990, and October 29, 2008. Of these 41 measurements, none were considered to be outliers because none had values greater than 31.25 µg/L. So, the criterion was derived using a final dataset consisting of 41 chlorophyll *a* measurements collected between between July 24, 1990, and October 29, 2008, all of which were equal to or below 30.6 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for pH and DO listings in the 2000 through 2010 reporting cycles, the following 303(d) listings were identified for Lake Cypress Springs:

Year	Parameter	Assessment Unit	Assessment Unit Description
2006	DO	0405_03	Panther Arm
2008	DO	0405_03	Panther Arm

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Lake Cypress Springs:

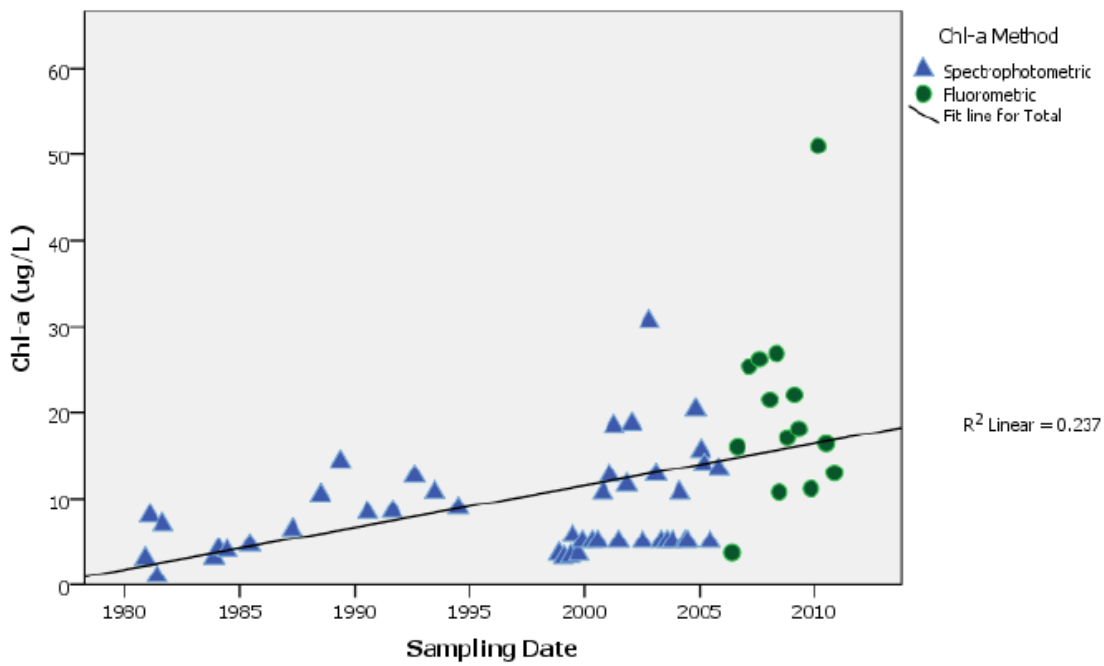
Year	Parameter	Assessment Unit	Assessment Unit Description
2006	DO	0405_02	Upper 2600 acres
2008	DO	0405_02	Upper 2600 acres
2010	DO	0405_02	Upper 2600 acres
2006	NO3-N	0405_02	Upper 2600 acres
2010	pH	0405_02	Upper 2600 acres
2008	DO	0405_03	Panther Arm
2006	NH3-N	0405_03	Panther Arm
2008	NH3-N	0405_03	Panther Arm

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Lake Cypress Springs in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Lake Cypress Springs was not sampled as part of the 2007 NLA.

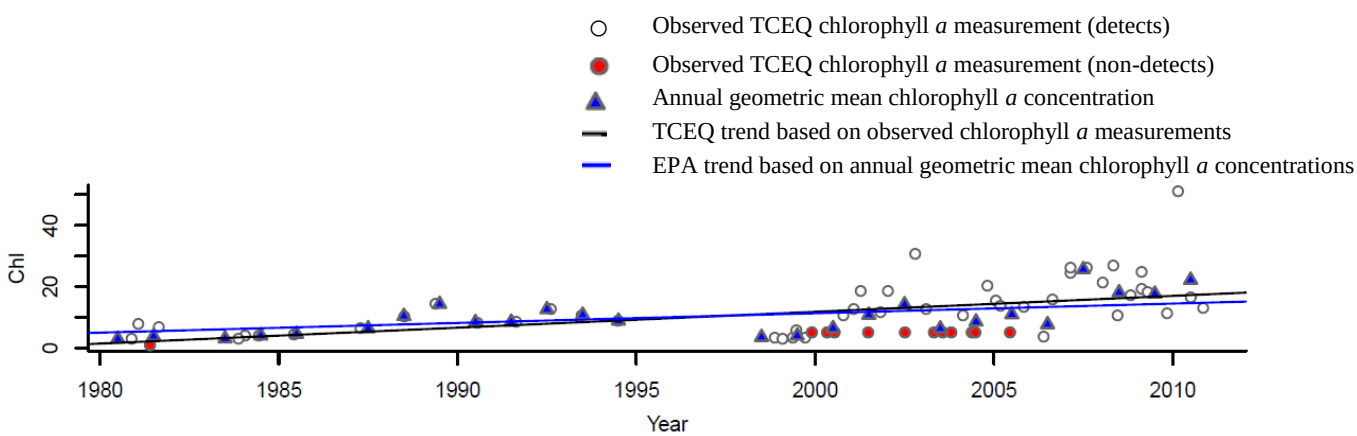
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 58 chlorophyll *a* measurements collected from Lake Cypress Springs between 1980 and 2010 (see Figure 97). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Lake Cypress Springs. Based upon the supporting information provided by TCEQ, a shift in methodology does appear to have occurred for this dataset in 2006 (with all data after 2006 being collected using the fluorometric method rather than the spectrophotometric method). Forty-four chlorophyll *a* measurements were made using the spectrophotometric method, with 12 of these measurements (~27%) being reported as less than the minimum reporting limits. Fourteen measurements were made using the fluorometric method, with none of these measurements (0%) being reported as less than the minimum reporting limits. When TCEQ analyzed trends for each of these datasets separately, the chlorophyll *a* data collected using the fluorometic method did not show a statistically significant increasing trend, while the chlorophyll *a* data collected using the spectrophotometric method did show a statistically significant increasing trend. In further analyzing the spectrophotometric method dataset, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) affected the statistical significance of this chlorophyll *a* trend to such a degree that the increasing trend for Lake Cypress Springs was no longer considered statistically significant.

Figure 97. Chlorophyll *a* Trend for Lake Cypress Springs Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Lake Cypress Springs based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 98). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Lake Cypress Springs, the magnitude of the slope of this increasing trend was relatively high at 0.315 µg/L chlorophyll *a*/year.

Figure 98. Chlorophyll *a* Trends for Lake Cypress Springs Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Lake Cypress Springs was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Lake Cypress Springs between the 2000 and 2010 reporting cycles. According to

the report, a Carlson's TSI value of 52.82 was determined for the 2010 reporting cycle for Lake Cypress Springs. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 3.87 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Lake Cypress Springs was eutrophic for both the 2000 and 2010 reporting cycles.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Lake Cypress Springs, the chlorophyll *a* criterion is below 30 µg/L but 2% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Lake Cypress Springs, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of Lake Cypress Springs. Reservoir-specific data and information described above indicates a eutrophic classification for Lake Cypress Springs, with a relatively high rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.315 µg/L chlorophyll *a*/year) and an increasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. TCEQ identified two CWA §303(d) listings for DO in Lake Cypress Springs in the 2006 through 2008 reporting cycles, as well as four concerns for DO and one concern for pH in the 2006 through 2010 reporting cycles. TCEQ also identified three concerns for nutrients (NH3-N and NO3-N) in Lake Cypress Springs in the 2006 through 2008 reporting cycles, but these were not repeating. Only 2% of the measurements in the underlying chlorophyll *a* dataset available for Lake Cypress Springs were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is satisfied in the case of Lake Cypress Springs, EPA strongly considered the fact that the three nutrient concerns that TCEQ identified were not repeating (as previously defined in Footnote 2) and the fact that only 2% of the measurements in the underlying chlorophyll *a* dataset available for Lake Cypress Springs were greater than 30 µg/L. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 17.54 µg/L applicable to Lake Cypress Springs is protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

50. <u>Whitney Lake, Segment 1203, Chlorophyll *a* Criterion 18.34 µg/L (Disapproved)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 50 measurements collected between between July 10, 1990, and November 12, 2008. Of these 50 measurements, 2 were considered to be outliers because they had values greater than 35.6875 µg/L. So, the criterion was derived using a final dataset consisting of 48 chlorophyll *a* measurements collected between between July 10, 1990, and November 12, 2008, all of which were equal to or below 31.5 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Whitney Lake.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles,

the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Whitney Lake:

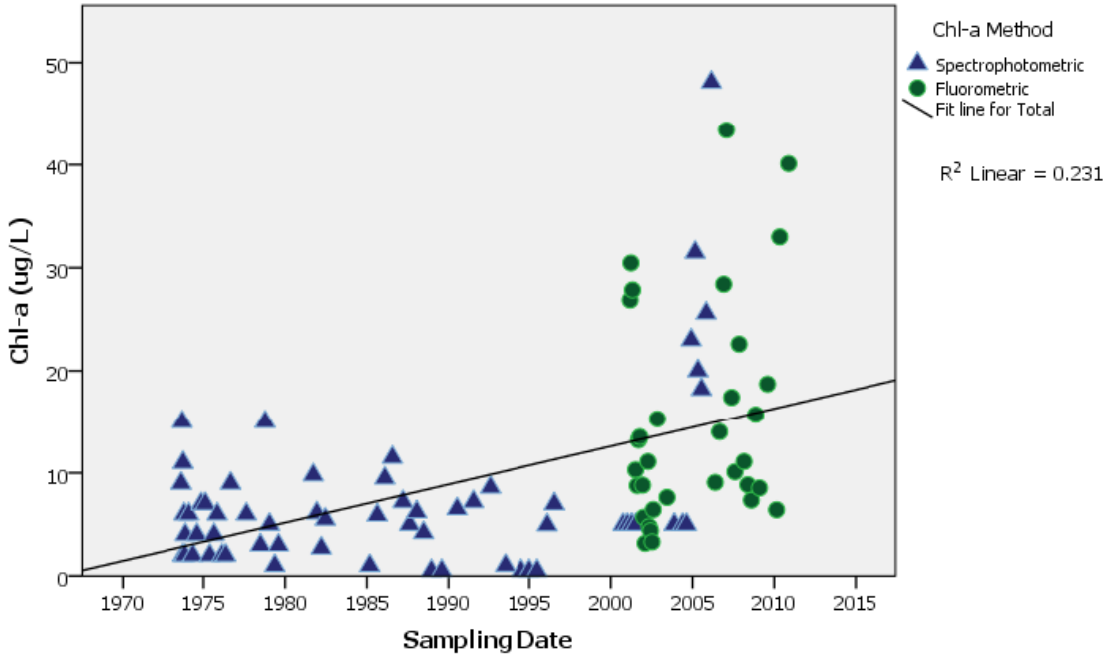
Year	Parameter	Assessment Unit	Assessment Unit Description
2008	DO	1203_01	Portion near dam
2010	DO	1203_01	Portion near dam
2010	Chl-a	1203_03	Steele Creek Arm
2006	Chl-a	1203_05	Nolan River Arm
2008	Chl-a	1203_05	Nolan River Arm
2010	Chl-a	1203_05	Nolan River Arm
2006	NO3-N	1203_05	Nolan River Arm
2008	NO3-N	1203_05	Nolan River Arm
2008	Chl-a	1203_06	Brazos River Arm
2010	Chl-a	1203_06	Brazos River Arm

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Whitney Lake in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Whitney Lake was sampled one time as part of the 2007 NLA. Chlorophyll *a* concentration data was not available for this sampling event. The microcystin concentration during sampling was below the reporting limit of 0.1 µg/L, indicating a low risk of exposure based on the microcystin thresholds used in the NLA study. The cyanobacteria cell count during sampling was between 20,000 and 100,000 cells per milliliter, indicating a moderate risk of exposure based on the cyanobacteria thresholds used in the NLA study.

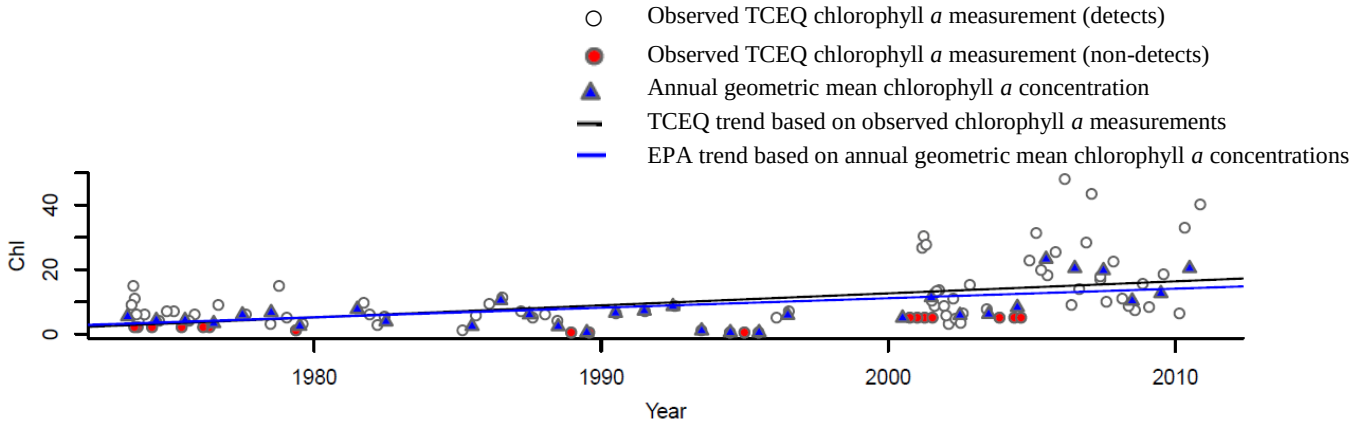
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 93 chlorophyll *a* measurements collected from Whitney Lake between 1973 and 2010 (see Figure 99). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Whitney Lake. Based upon the supporting information provided by TCEQ, a shift in methodology does appear to have occurred for this dataset in 2001 (with most data after 2001 being collected using the fluorometric method rather than the spectrophotometric method). Sixty chlorophyll *a* measurements were made using the spectrophotometric method, with 19 of these measurements (~32%) being reported as less than the minimum reporting limits. Thirty-three measurements were made using the fluorometric method, with none of these measurements (0%) being reported as less than the minimum reporting limits. When TCEQ analyzed trends for each of these datasets separately, the chlorophyll *a* data collected using the fluorometic method did not show a statistically significant increasing trend, while the chlorophyll *a* data collected using the spectrophotometric method did show a statistically significant increasing trend. In further analyzing the spectrophotometric method dataset, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) did not affect the statistical significance of this chlorophyll *a* trend to such a degree that the trend became statistically insignificant. Therefore, EPA believes that this increasing trend for Whitney Lake is statistically significant.

Figure 99. Chlorophyll *a* Trend for Whitney Lake Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Whitney Lake based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 100). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Whitney Lake, the magnitude of the slope of this increasing trend was relatively high at 0.296 µg/L chlorophyll *a*/year.

Figure 100. Chlorophyll *a* Trends for Whitney Lake Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Whitney Lake was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Whitney Lake between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 57.48 was determined for the 2010 reporting cycle for Whitney Lake. This value

was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 17.52 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Whitney Lake shifted from a mesotrophic classification for the 2000 reporting cycle to a hypereutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Whitney Lake, the chlorophyll *a* criterion is below 30 µg/L but 5% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Whitney Lake, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is not satisfied in the case of Whitney Lake. Reservoir-specific data and information described above indicates a mesotrophic classification for Whitney Lake in the 2000 reporting cycle with a shift to a hypereutrophic classification in the 2010 reporting cycle. Reservoir-specific data and information described above indicates a relatively high rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.296 µg/L chlorophyll *a*/year) and a statistically significant increasing trend in chlorophyll *a* concentration based on EPA's review of TCEQ's trend analysis. TCEQ did not identify any CWA §303(d) listings for pH or DO for Whitney Lake. TCEQ identified eight concerns for DO and chlorophyll *a* in Whitney Lake in the 2006 through 2010 reporting cycles. And, though not considered repeating (as previously defined in Footnote 2), TCEQ identified two nutrient concerns (NO3-N) in the 2006 through 2008 reporting cycles in Nolan River Arm of Whitney Lake. 2007 NLA data for Whitney Lake indicated a low risk of exposure based on microcystin thresholds and a moderate risk of exposure based on cyanobacteria thresholds. 5% of the measurements in the underlying chlorophyll *a* dataset available for Whitney Lake were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is not satisfied in the case of Whitney Lake, EPA strongly considered the shift to a hypereutrophic classification in the 2010 reporting cycle, along with the relatively high rate of chlorophyll a accumulation based on EPA's trend analysis (slope = 0.296 µg/L chlorophyll *a*/year). Based on the above information, EPA concludes that the chlorophyll *a* criterion of 18.34 µg/L applicable to Whitney Lake is not protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA disapproves this reservoir-specific chlorophyll *a* criterion.

51. <u>Lewisville Lake, Segment 0823, Chlorophyll *a* Criterion 18.45 µg/L (Disapproved)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 43 measurements collected between between May 17, 1972, and October 30, 2001. Of these 43 measurements, none were considered to be outliers because none had values greater than 30.825 µg/L. So, the criterion was derived using a final dataset consisting of 43 chlorophyll *a* measurements collected between between May 17, 1972, and October 30, 2001, all of which were equal to or below 28.5 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Lewisville Lake.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Lewisville Lake:

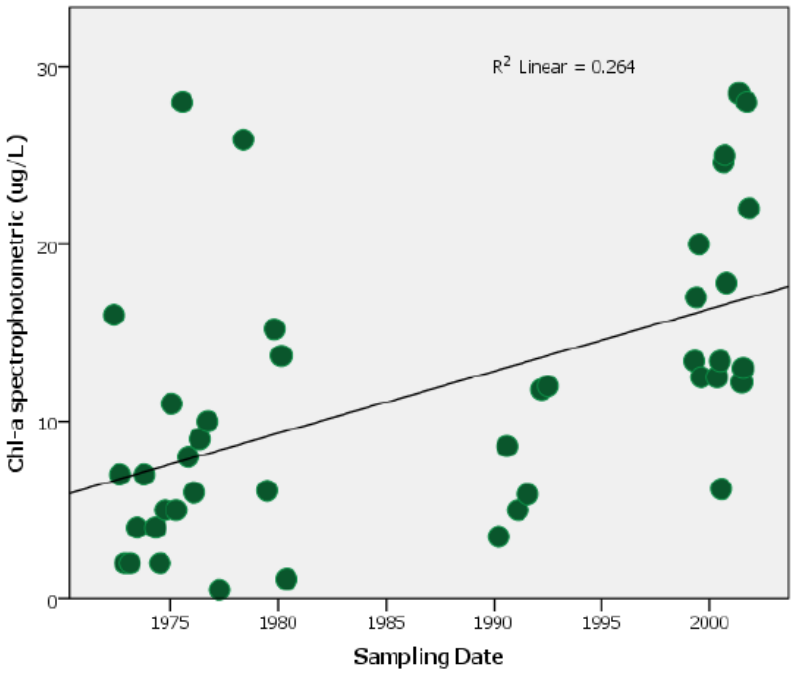
Year	Parameter	Assessment Unit	Assessment Unit Description
2006	NH3-N	0823_02	Stewart Creek arm
2008	NH3-N	0823_02	Stewart Creek arm
2010	NH3-N	0823_02	Stewart Creek arm
2006	NO3-N	0823_02	Stewart Creek arm
2008	NO3-N	0823_02	Stewart Creek arm
2010	NO3-N	0823_02	Stewart Creek arm
2006	OP	0823_02	Stewart Creek arm
2008	OP	0823_02	Stewart Creek arm
2010	OP	0823_02	Stewart Creek arm
2006	TP	0823_02	Stewart Creek arm
2008	TP	0823_02	Stewart Creek arm
2010	TP	0823_02	Stewart Creek arm
2006	NO3-N	0823_04	Little Elm Creek arm
2008	NO3-N	0823_04	Little Elm Creek arm
2010	NO3-N	0823_04	Little Elm Creek arm

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Lewisville Lake in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Lewisville Lake was sampled one time as part of the 2007 NLA. The chlorophyll *a* concentration measured during sampling was 30.24 µg/L, indicating a moderate risk of exposure based on the chlorophyll *a* thresholds used in the NLA study. The microcystin concentration during sampling was below the reporting limit of 0.1 µg/L, indicating a low risk of exposure based on the microcystin thresholds used in the NLA study. The cyanobacteria cell count during sampling was less than 20,000 cells per milliliter, indicating a low risk of exposure based on the cyanobacteria thresholds used in the NLA study.

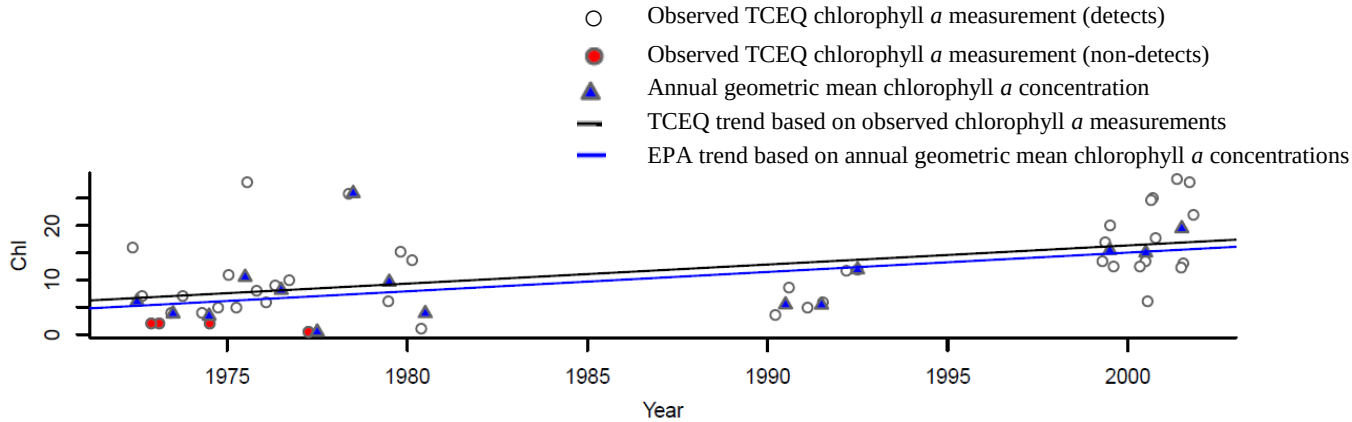
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 43 chlorophyll *a* measurements collected from Lewisville Lake between 1972 and 2001 (see Figure 101). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Lewisville Lake. Based upon the supporting information provided by TCEQ, all of these chlorophyll *a* measurements were determined using the same method (spectrophotometric). Four of these 43 measurements (9%) were reported as being less than the reporting limits. In further analyzing the spectrophotometric method dataset, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) did not affect the statistical significance of this chlorophyll *a* trend to such a degree that the trend became statistically insignificant. Therefore, EPA believes that this increasing trend for Lewisville Lake is statistically significant.

Figure 101. Chlorophyll *a* Trend for Lewisville Lake Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Lewisville Lake based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 102). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Lewisville Lake, the magnitude of the slope of this increasing trend was relatively hight at 0.355 µg/L chlorophyll *a*/year.

Figure 102. Chlorophyll *a* Trends for Lewisville Lake Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Lewisville Lake was not included in TCEQ's report titled *Trophic Classification of Texas Reservoirs*.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix

and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Lewisville Lake, the chlorophyll *a* criterion is below 30 µg/L and 0% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Lewisville Lake, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is not satisfied in the case of Lewisville Lake. Trophic state classification information was not available for Lewisville Lake. Reservoir-specific data and information described above indicates a relatively high rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.355 µg/L chlorophyll *a*/year) and a statistically significant increasing trend in chlorophyll *a* concentration based on EPA's review of TCEQ's trend analysis. TCEQ did not identify any CWA §303(d) listings for pH or DO for Lewisville Lake. However, TCEQ did identify 15 concerns for nutrients (NH3-N, NO3-N, OP, and TP) in Lewisville Lake that were repeating. 2007 NLA data for Lewisville Lake indicated a moderate risk of exposure based on chlorophyll *a* thresholds, and a low risk of exposure based on microcystin and cyanobacteria thresholds. None of the measurements in the underlying chlorophyll *a* dataset available for Lewisville Lake were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is not satisfied in the case of Lewisville Lake, EPA strongly considered the relatively high rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.355 µg/L chlorophyll *a*/year) in combination with TCEQ's identification of 15 nutrient concerns that were repeating. These two information sources indicate both the presence of nutrients in concentrations of concern to TCEQ and a biological response in the form of a relatively high chlorophyll *a* accumulation rate. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 18.45 µg/L applicable to Lewisville Lake is not protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA disapproves this reservoir-specific chlorophyll *a* criterion.

52. Lake Pat Cleburne, Segment 1228, Chlorophyll *a* Criterion 19.04 µg/L (Approved*)

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 53 measurements collected between between September 13, 1973, and December 2, 2008. Of these 53 measurements, 4 were considered to be outliers because they had values greater than 37 µg/L. So, the criterion was derived using a final dataset consisting of 49 chlorophyll *a* measurements collected between between September 13, 1973, and December 2, 2008, all of which were equal to or below 36.4 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Lake Pat Cleburne.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Lake Pat Cleburne:

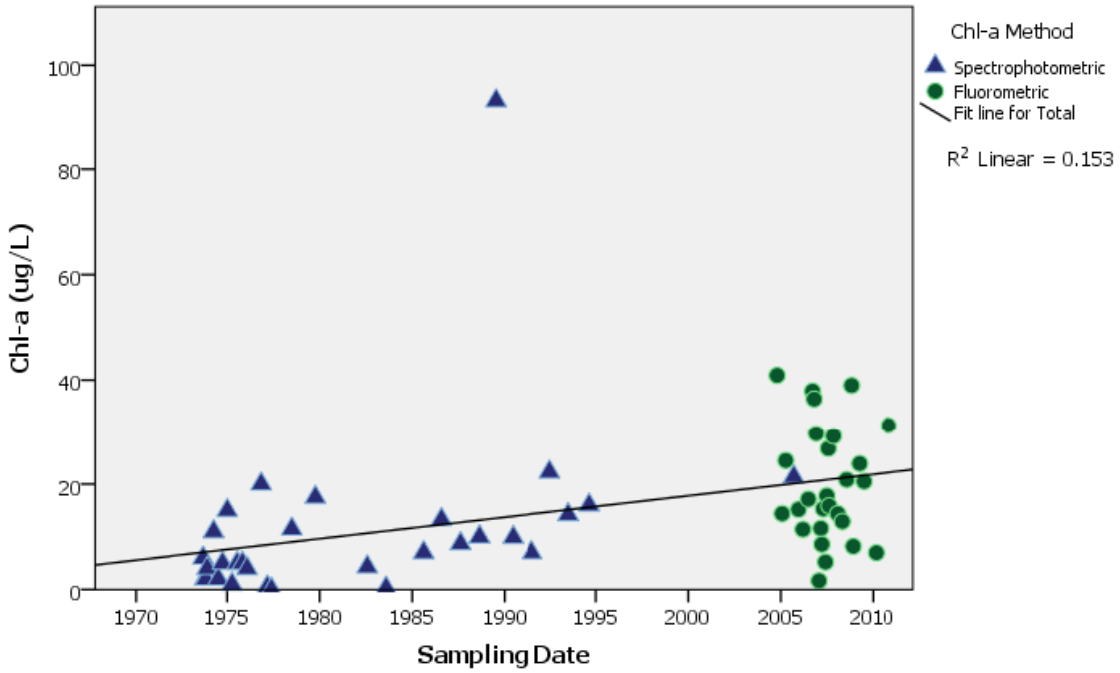
Year	Parameter	Assessment Unit	Assessment Unit Description
2010	Chl-a	1228_01	Entire water body

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Lake Pat Cleburne in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Lake Pat Cleburne was not sampled as part of the 2007 NLA.

TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 57 chlorophyll *a* measurements collected from Lake Pat Cleburne between 1973 and 2010 (see Figure 103). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Lake Pat Cleburne. Based upon the supporting information provided by TCEQ, a shift in methodology does appear to have occurred for this dataset in 2004 (with most data after 2004 being collected using the fluorometric method rather than the spectrophotometric method). Thirty chlorophyll *a* measurements were made using the spectrophotometric method, with 5 of these measurements (~17%) being reported as less than the minimum reporting limits. Twenty-seven measurements were made using the fluorometric method, with 1 of these measurements (~4%) being reported as less than the minimum reporting limits. When TCEQ analyzed trends for each of these datasets separately, the chlorophyll *a* data collected using the fluorometic method did not show a statistically significant increasing trend, while the chlorophyll *a* data collected using the spectrophotometric method did show a statistically significant increasing trend. In further analyzing the spectrophotometric method dataset, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) did not affect the statistical significance of this chlorophyll *a* trend to such a degree that the trend became statistically insignificant. Therefore, EPA believes that this increasing trend for Lake Pat Cleburne is statistically significant.

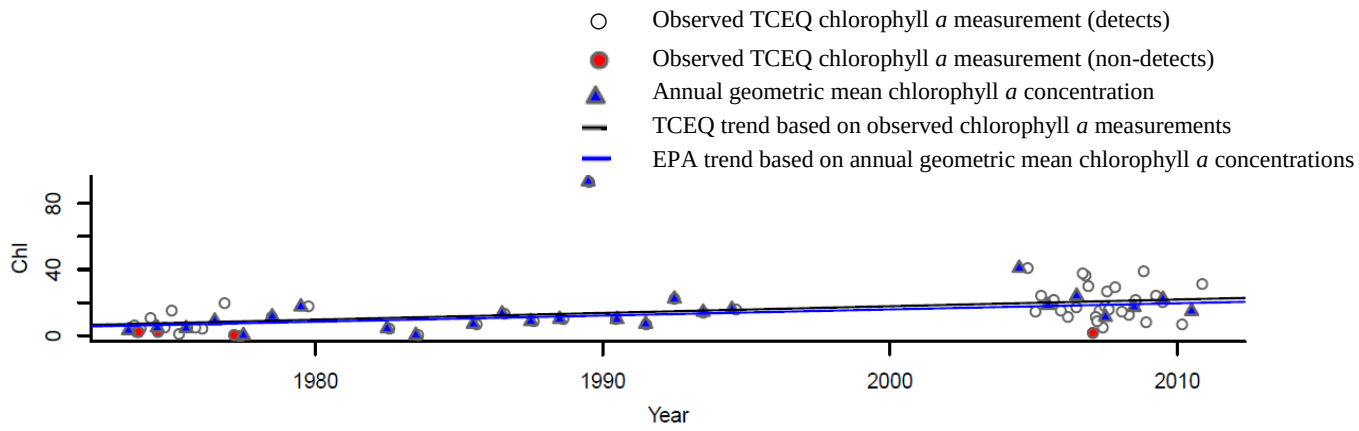
Figure 103. Chlorophyll *a* Trend for Lake Pat Cleburne Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Lake Pat Cleburne based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 104). Note that each annual geometric mean chlorophyll *a* concentration was

weighted by the number of samples used to compute each average. For Lake Pat Cleburne, the magnitude of the slope of this increasing trend was relatively high at 0.373 µg/L chlorophyll *a*/year.

Figure 104. Chlorophyll *a* Trends for Lake Pat Cleburne Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Lake Pat Cleburne was not included in TCEQ's report titled *Trophic Classification of Texas Reservoirs*.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Lake Pat Cleburne, the chlorophyll *a* criterion is below 30 µg/L but 9% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Lake Pat Cleburne, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of Lake Pat Cleburne. Trophic state classification information was not available for Lake Pat Cleburne. Reservoir-specific data and information described above indicates a relatively high rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.373 µg/L chlorophyll *a*/year) and a statistically significant increasing trend in chlorophyll *a* concentration based on EPA's review of TCEQ's trend analysis. However, TCEQ did not identify any CWA §303(d) listings for pH or DO for Lake Pat Cleburne, and only identified one concern for chlorophyll *a* in Lake Pat Cleburne in the 2010 reporting cycle. TCEQ did not identify concerns for any other nutrient-enrichment related indicators or any nutrient indicators. 9% of the measurements in the underlying chlorophyll *a* dataset available for Lake Lake Pat Cleburne were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is satisfied in the case of Lake Pat Cleburne, EPA strongly considered the fact that TCEQ did not identify any nutrient concerns. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 19.04 µg/L applicable to Lake Pat Cleburne is protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

53. <u>Lake Limestone, Segment 1252, Chlorophyll *a* Criterion 19.26 µg/L (Disapproved)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 58 measurements collected between between June 13, 1990, and July 15, 2008. Of these 58 measurements, 4 were considered to be outliers because they had values greater than

33.55375 µg/L. So, the criterion was derived using a final dataset consisting of 54 chlorophyll *a* measurements collected between between July 17, 1991, and April 22, 2008, all of which were equal to or below 32.5 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Lake Limestone.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Lake Limestone:

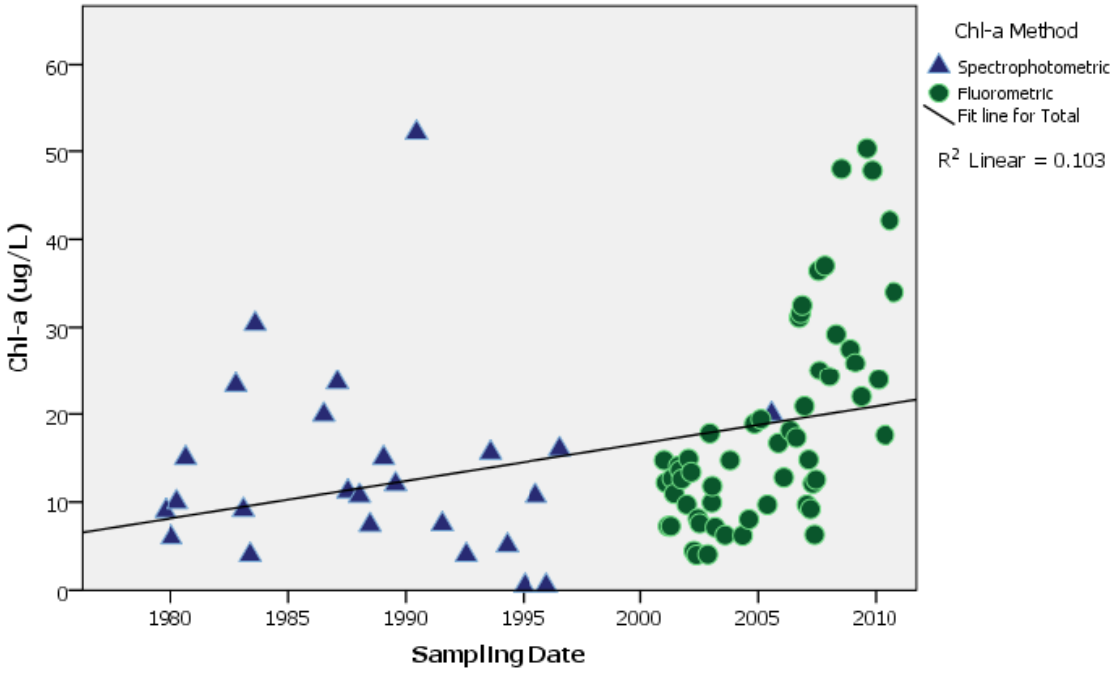
Year	Parameter	Assessment Unit	Assessment Unit Description
2008	DO	1252_01	South end of lake near dam
2010	DO	1252_01	South end of lake near dam
2006	NO3-N	1252_01	South end of lake near dam
2010	Chl-a	1252_02	Main body of lake
2010	Chl-a	1252_03	Lambs Creek arm on east side of lake
2008	Chl-a	1252_05	Navasota River Arm near headwaters
2010	Chl-a	1252_05	Navasota River Arm near headwaters

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Lake Limestone in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Lake Limestone was not sampled as part of the 2007 NLA.

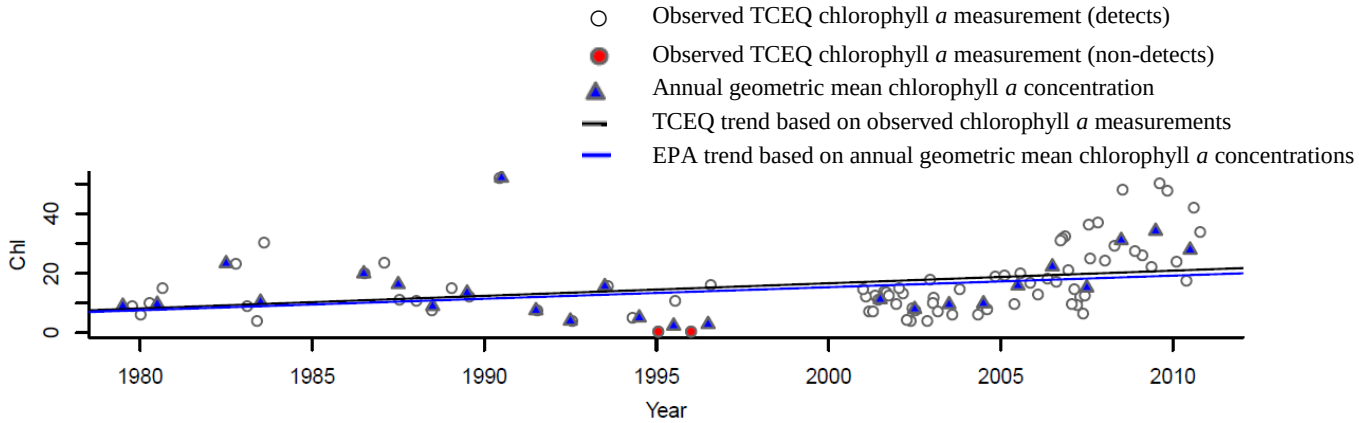
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 82 chlorophyll *a* measurements collected from Lake Limestone between 1979 and 2010 (see Figure 105). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Lake Limestone. Based upon the supporting information provided by TCEQ, a shift in methodology does appear to have occurred for this dataset in 2001 (with most data after 2001 being collected using the fluorometric method rather than the spectrophotometric method). Twenty-seven chlorophyll *a* measurements were made using the spectrophotometric method, with 2 of these measurements (~7%) being reported as less than the minimum reporting limits. Fifty-five measurements were made using the fluorometric method, with none of these measurements (0%) being reported as less than the minimum reporting limits. When TCEQ analyzed trends for each of these datasets separately, the chlorophyll *a* data collected using the spectrophotometric method did not show a statistically significant increasing trend, while the chlorophyll *a* data collected using the fluorometic method did show a statistically significant increasing trend. Because no data were reported as being less than reporting limits within the fluorometric dataset, EPA believes that the increasing trend for Lake Limestone is statistically significant.

Figure 105. Chlorophyll *a* Trend for Lake Limestone Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Lake Limestone based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 106). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Lake Limestone, the magnitude of the slope of this increasing trend was relatively high at 0.388 µg/L chlorophyll *a*/year.

Figure 106. Chlorophyll *a* Trends for Lake Limestone Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Lake Limestone was not included in TCEQ's report titled *Trophic Classification of Texas Reservoirs*.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix

and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Lake Limestone, the chlorophyll *a* criterion is below 30 µg/L but 11% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Lake Limestone, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is not satisfied in the case of Lake Limestone. Trophic state classification information was not available for Lake Limestone. Reservoir-specific data and information described above indicates a relatively high rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.388 µg/L chlorophyll *a*/year) and a statistically significant increasing trend in chlorophyll *a* concentration based on EPA's review of TCEQ's trend analysis. TCEQ did not identify any CWA §303(d) listings for pH or DO for Lake Limestone. While TCEQ only identified one nutrient concern (NO3-N) in Lake Limestone in the 2006 reporting cycle, TCEQ did identify six concerns for DO and chlorophyll *a* in Lake Limestone in the 2008 through 2010 reporting cycles. 11% of the measurements in the underlying chlorophyll *a* dataset available for Lake Limestone were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is not satisfied in the case of Lake Limestone, EPA strongly considered this last information source. With 11% of the measurements in the underlying chlorophyll *a* dataset available for Lake Limestone being greater than 30 µg/L, EPA is concerned that the chlorophyll *a* criterion (which is derived and expressed as a long-term central tendency), is not likely to protect designated uses from the effects of high instantaneous chlorophyll *a* concentrations (such as nuisance blooms, toxic cyanobacteria and toxin production, taste and odor compound production, and disinfection byproduct production). Based on the above information, EPA concludes that the chlorophyll *a* criterion of 19.26 µg/L applicable to Lake Limestone is not protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA disapproves this reservoir-specific chlorophyll *a* criterion.

54. <u>Lake Waxahachie, Segment 0816, Chlorophyll *a* Criterion 19.77 µg/L (Approved*)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 34 measurements collected between between June 25, 1990, and December 1, 2008. Of these 34 measurements, 1 was considered to be an outlier because it had a value greater than 39.875 µg/L. So, the criterion was derived using a final dataset consisting of 33 chlorophyll *a* measurements collected between between June 25, 1990, and December 1, 2008, all of which were equal to or below 35.2 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Lake Waxahachie.

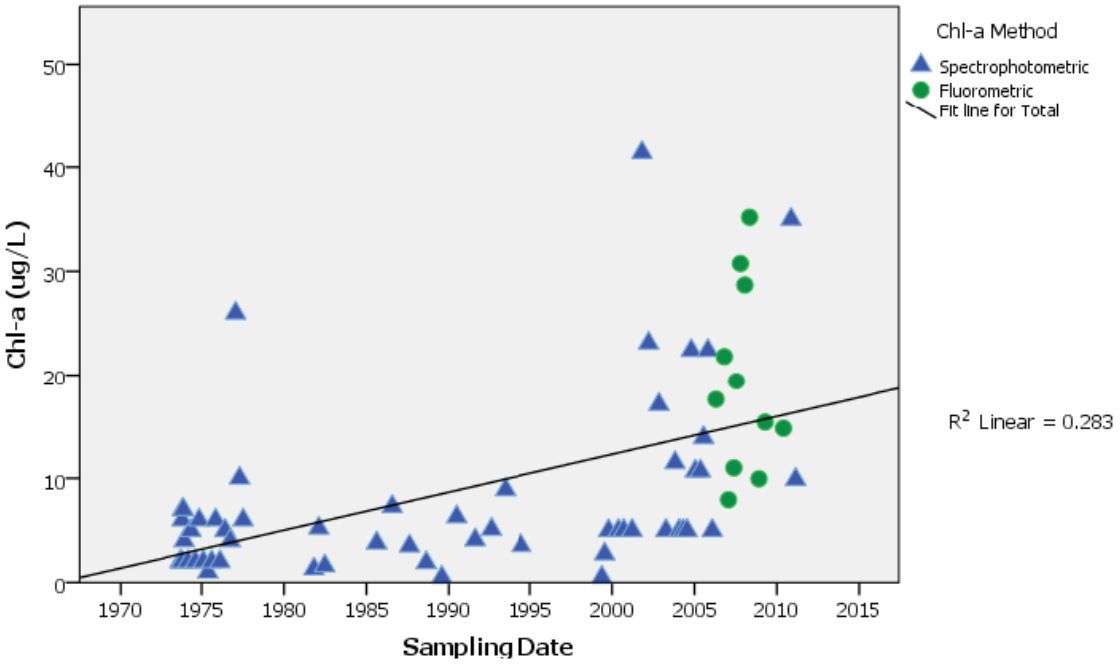
Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, no water quality concerns for any nutrient or nutrient enrichment-related indicators were identified for Lake Waxahachie.

Treated Drinking Water Chemical Data: No information regarding occurrences of SDWA MCL exceedances was available for Lake Waxahachie in TCEQ's supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Lake Waxahachie was not sampled as part of the 2007 NLA.

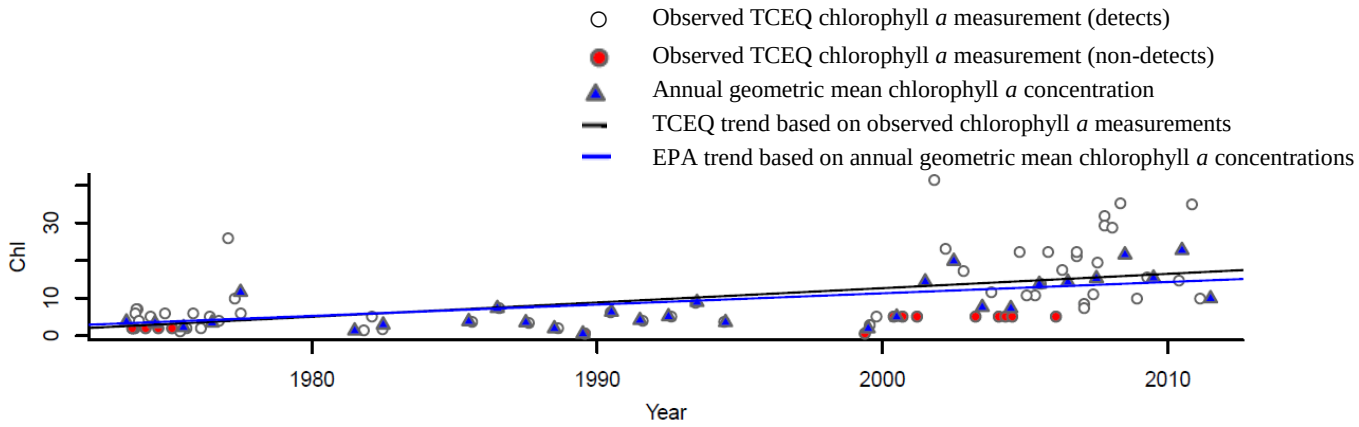
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 67 chlorophyll *a* measurements collected from Lake Waxahachie between 1973 and 2011 (see Figure 107). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Lake Waxahachie. Based upon the supporting information provided by TCEQ, a shift in methodology does appear to have occurred for this dataset in 2006 (with most data after 2006 being collected using the fluorometric method rather than the spectrophotometric method). Fifty-six chlorophyll *a* measurements were made using the spectrophotometric method, with 16 of these measurements (~29%) being reported as less than the minimum reporting limits. Eleven measurements were made using the fluorometric method, with none of these measurements (0%) being reported as less than the minimum reporting limits. When TCEQ analyzed trends for each of these datasets separately, the chlorophyll *a* data collected using the fluorometic method did not show a statistically significant increasing trend, while the chlorophyll *a* data collected using the spectrophotometric method did show a statistically significant increasing trend. In further analyzing the spectrophotometric method dataset, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) did not affect the statistical significance of this chlorophyll *a* trend to such a degree that the trend became statistically insignificant. Therefore, EPA believes that this increasing trend for Lake Waxahachie is statistically significant.

Figure 107. Chlorophyll *a* Trend for Lake Waxahachie Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Lake Waxahachie based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 108). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Lake Waxahachie, the magnitude of the slope of this increasing trend was relatively high at 0.301 µg/L chlorophyll *a*/year.

Figure 108. Chlorophyll *a* Trends for Lake Waxahachie Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Lake Waxahachie was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Lake Waxahachie between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 54.18 was determined for the 2010 reporting cycle for Lake Waxahachie. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 11.94 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Lake Waxahachie shifted from a mesotrophic classification for the 2000 reporting cycle to a eutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Lake Waxahachie, the chlorophyll *a* criterion is below 30 µg/L but 3% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Lake Waxahachie, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is satisfied in the case of Lake Waxahachie. Reservoir-specific data and information described above indicates a mesotrophic classification for Lake Waxahachie in the 2000 reporting cycle with a shift to a eutrophic classification in the 2010 reporting cycle. Reservoir-specific data and information described above indicates a relatively high rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.301 µg/L chlorophyll *a*/year) and a statistically significant increasing trend in chlorophyll *a* concentration based on EPA's review of TCEQ's trend analysis. However, TCEQ did not identify any CWA §303(d) listings for pH or DO for Lake Waxahachie, nor did it identify any concerns for nutrient or nutrient-enrichment related indicators. Further, only 3% of the measurements in the underlying chlorophyll *a* dataset available for Lake Waxahachie were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is satisfied in the case of Lake Waxahachie, EPA strongly considered the fact that TCEQ did not identify any nutrient concerns and the fact that only 3% of the measurements in the underlying chlorophyll *a* dataset available for Lake Waxahachie were greater than 30 µg/L. Based on the above information, EPA concludes that the

chlorophyll *a* criterion of 19.77 µg/L applicable to Lake Waxahachie is protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA approves this reservoir-specific chlorophyll *a* criterion.

55. Wright Patman Lake, Segment 0302, Chlorophyll *a* Criterion 21.49 µg/L (Disapproved)

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 44 measurements collected between between October 18, 1973, and January 11, 2000. Of these 44 measurements, 3 were considered to be outliers because they had values greater than 48.655 µg/L. So, the criterion was derived using a final dataset consisting of 41 chlorophyll *a* measurements collected between between October 18, 1973, and January 11, 2000, all of which were equal to or below 36 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for pH and DO listings in the 2000 through 2010 reporting cycles, the following 303(d) listings were identified for Wright Patman Lake:

Year	Parameter	Assessment Unit	Assessment Unit Description
2000	DO	n/a	400-acre area near the dam
2002	DO	n/a	400 acres, south dam
2004	DO	n/a	400 acres, south dam
2006	DO	0302_01	800 acres near dam
2004	DO	n/a	300 Acres at International Paper Intake
2006	DO	0302_02	300 Acres at International Paper Intake
2008	DO	0302_02	300 Acres at International Paper Intake
2010	DO	0302_02	300 Acres at International Paper Intake
2008	pH	0302_02	300 Acres at International Paper Intake
2010	pH	0302_02	300 Acres at International Paper Intake
2000	high pH	n/a	2,350-acre arm northwest of the dam
2002	high pH	n/a	2300 acres in arm, west of dam
2004	high pH	n/a	2300 acres in arm, west of dam
2002	high pH	n/a	500 acres in northeast corner of lake
2004	high pH	n/a	500 acres in northeast corner of lake
2006	pH	0302_04	500 acres in northeast corner of lake
2008	pH	0302_04	500 acres in northeast corner of lake
2010	pH	0302_04	500 acres in northeast corner of lake
2000	DO	n/a	123-acre area in the northwestern-most tip of the reservoir
2000	high pH	n/a	123-acre area in the northwestern-most tip of the reservoir
2002	DO	n/a	200 acres in the northwestern tip of lake
2004	DO	n/a	200 acres in the northwestern tip of lake
2002	high pH	n/a	200 acres in the northwestern tip of lake
2004	high pH	n/a	200 acres in the northwestern tip of lake
2006	pH	0302_05	200 acres in the northwestern tip of lake
2008	pH	0302_05	200 acres in the northwestern tip of lake
2010	pH	0302_05	200 acres in the northwestern tip of lake
2006	pH	0302_06	Big Creek Arm
2008	pH	0302_06	Big Creek Arm
2010	pH	0302_06	Big Creek Arm
2000	high pH	n/a	3,726-acre area in the middle of the reservoir
2002	high pH	n/a	4000 acres mid-lake
2004	high pH	n/a	4000 acres mid-lake
2006	pH	0302_07	4000 acres mid-lake
2008	pH	0302_07	4000 acres mid-lake

Year	Parameter	Assessment Unit	Assessment Unit Description
2010	pH	0302_07	4000 acres mid-lake
2000	DO	n/a	3,381-acre area in the upper middle portion of the reservoir
2000	high pH	n/a	3,381-acre area in the upper middle portion of the reservoir
2002	DO	n/a	1600 acres in upper mid-lake
2004	DO	n/a	1600 acres in upper mid-lake
2002	high pH	n/a	1600 acres in upper mid-lake
2004	high pH	n/a	1600 acres in upper mid-lake
2006	pH	0302_08	1600 acres in upper mid-lake
2008	pH	0302_08	1600 acres in upper mid-lake
2010	pH	0302_08	1600 acres in upper mid-lake
2000	DO	n/a	Upper 6,693 acres of the reservoir
2002	DO	n/a	4000 acres in upper portion of lake
2004	DO	n/a	4000 acres in upper portion of lake
2006	DO	0302_10	4000 acres in upper portion of lake
2008	DO	0302_10	4000 acres in upper portion of lake
2010	DO	0302_10	4000 acres in upper portion of lake

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Wright Patman Lake:

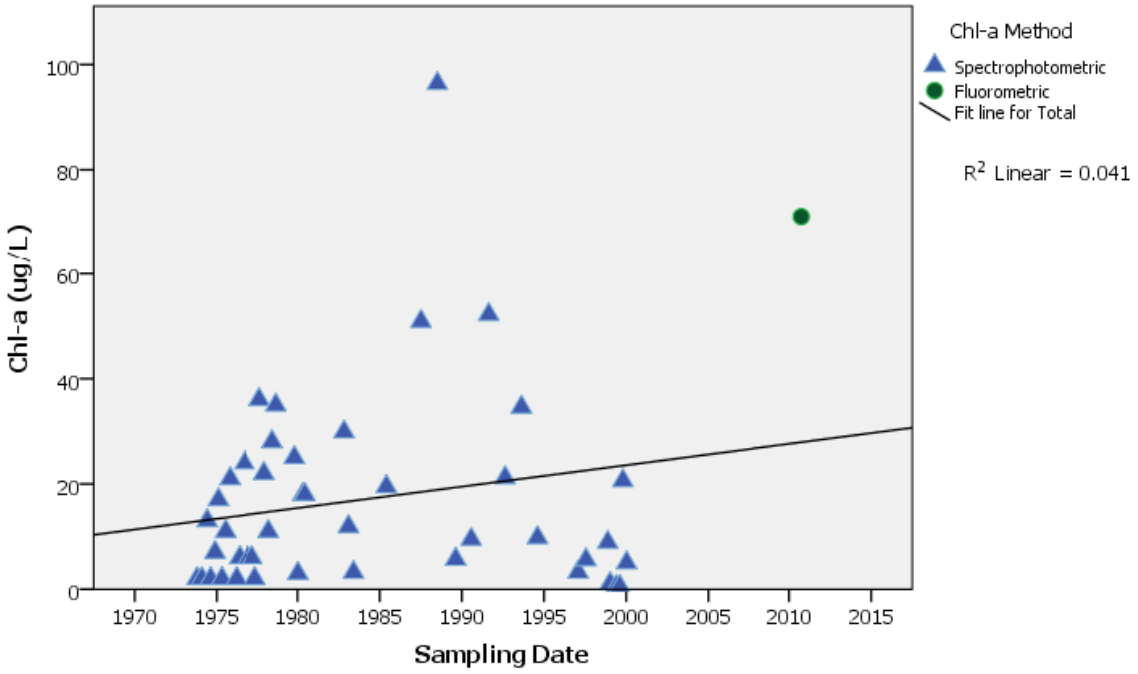
Year	Parameter	Assessment Unit	Assessment Unit Description
2008	Chl-a	0302_01	800 acres near dam
2010	Chl-a	0302_01	800 acres near dam
2010	pH	0302_01	800 acres near dam
2006	Chl-a	0302_02	300 acres at International Paper intake
2008	Chl-a	0302_02	300 acres at International Paper intake
2010	Chl-a	0302_02	300 acres at International Paper intake
2006	NH3-N	0302_02	300 acres at International Paper intake
2008	NH3-N	0302_02	300 acres at International Paper intake
2006	Chl-a	0302_04	500 acres in the northeast corner of lake
2008	Chl-a	0302_04	500 acres in the northeast corner of lake
2010	Chl-a	0302_04	500 acres in the northeast corner of lake
2006	NH3-N	0302_04	500 acres in the northeast corner of lake
2008	NH3-N	0302_04	500 acres in the northeast corner of lake
2006	Chl-a	0302_06	Big Creek arm
2008	Chl-a	0302_06	Big Creek arm
2010	Chl-a	0302_06	Big Creek arm
2008	Chl-a	0302_09	5000 acres mid-lake, below Hwy 8
2010	Chl-a	0302_09	5000 acres mid-lake, below Hwy 8
2010	OP	0302_09	5000 acres mid-lake, below Hwy 8
2008	Chl-a	0302_10	4000 acres in upper portion of lake
2010	Chl-a	0302_10	4000 acres in upper portion of lake
2006	NH3-N	0302_10	4000 acres in upper portion of lake
2008	OP	0302_10	4000 acres in upper portion of lake
2010	OP	0302_10	4000 acres in upper portion of lake
2010	TP	0302_10	4000 acres in upper portion of lake

Treated Drinking Water Chemical Data: For facilities using source water from Wright Patman Lake, TCEQ did not report finding any exceedances of SDWA MCLs for any disinfection byproducts or nitrate in supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Wright Patman Lake was sampled one time as part of the 2007 NLA. The chlorophyll *a* concentration measured during sampling was 80.1 µg/L, indicating a high risk of exposure based on the chlorophyll *a* thresholds used in the NLA study. The microcystin concentration during sampling was below the reporting limit of 0.1 µg/L, indicating a low risk of exposure based on the microcystin thresholds used in the NLA study. The cyanobacteria cell count during sampling was between 20,000 and 100,000 cells per milliliter, indicating a moderate risk of exposure based on the cyanobacteria thresholds used in the NLA study.

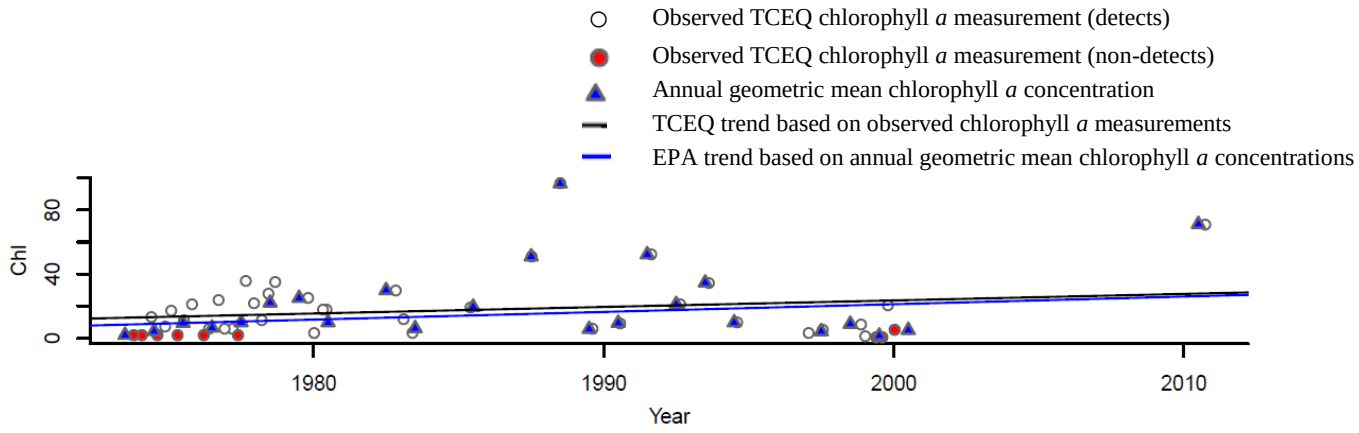
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ did not identify any statistically significant increasing trends in chlorophyll *a* concentrations for Wright Patman Lake (see Figure 109).

Figure 109. Chlorophyll *a* Trend for Wright Patman Lake Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Wright Patman Lake based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 110). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Wright Patman Lake, the magnitude of the slope of this increasing trend was very high, relatively speaking, at 0.479 µg/L chlorophyll *a*/year.

Figure 110. Chlorophyll *a* Trends for Wright Patman Lake Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Wright Patman Lake was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Wright Patman Lake between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 47.38 was determined for the 2010 reporting cycle for Wright Patman Lake. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 2.79 points lower than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Wright Patman Lake was eutrophic for both the 2000 and 2010 reporting cycles.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Wright Patman Lake, the chlorophyll *a* criterion is below 30 µg/L but 14% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Wright Patman Lake, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is not satisfied in the case of Wright Patman Lake. Reservoir-specific data and information described above indicates a eutrophic classification for Wright Patman Lake, with a very high rate of chlorophyll *a* accumulation, relatively speaking, based on EPA's trend analysis (slope = 0.479 µg/L chlorophyll *a*/year) and an increasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. TCEQ identified 51 CWA §303(d) listings for pH and DO for Wright Patman Lake in the 2000 through 2010 reporting cycles. TCEQ also identified 16 concerns for chlorophyll *a* and pH in Wright Patman Lake in the 2006 through 2010 reporting cycles. Additionally, TCEQ identified nine concerns for nutrients (NH3-N, OP, and TP) in Wright Patman Lake that were repeating. 2007 NLA data for Wright Patman Lake indicated a high risk of exposure based on chlorophyll *a* thresholds, a low risk of exposure based on microcystin thresholds, and a moderate risk of exposure based on cyanobacteria thresholds. Further, 14% of the measurements in the underlying chlorophyll *a* dataset available for Wright Patman Lake were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is not satisfied in the case of Wright Patman Lake, EPA strongly considered the very high rate of chlorophyll *a* accumulation, relatively speaking,

based on EPA's trend analysis (slope = 0.479 µg/L chlorophyll *a*/year) in combination with TCEQ's identification of nine nutrient concerns that were repeating. These two information sources indicate both the presence of nutrients in concentrations of concern to TCEQ and a biological response in the form of a relatively high chlorophyll *a* accumulation rate. Additionally, EPA also strongly considered the fact that 14% of the measurements in the underlying chlorophyll *a* dataset available for Wright Patman Lake were greater than 30 µg/L. With this being the case, EPA is concerned that the chlorophyll *a* criterion (which is derived and expressed as a long-term central tendency), is not likely to protect designated uses from the effects of high instantaneous chlorophyll *a* concentrations (such as nuisance blooms, toxic cyanobacteria and toxin production, taste and odor compound production, and disinfection byproduct production). Based on the above information, EPA concludes that the chlorophyll *a* criterion of 21.49 µg/L applicable to Wright Patman Lake is not protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA disapproves this reservoir-specific chlorophyll *a* criterion.

56. <u>Palo Duro Reservoir, Segment 0100, Chlorophyll *a* Criterion 21.73 µg/L (Disapproved)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 33 measurements collected between between July 10, 1991, and July 23, 2008. Of these 33 measurements, 2 were considered to be outliers because they had values greater than 44.75 µg/L. So, the criterion was derived using a final dataset consisting of 31 chlorophyll *a* measurements collected between between July 10, 1991, and January 8, 2008, all of which were equal to or below 39.4 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for pH and DO listings in the 2000 through 2010 reporting cycles, the following 303(d) listings were identified for Palo Duro Reservoir:

Year	Parameter	Assessment Unit	Assessment Unit Description
2000	DO	n/a	Entire reservoir
2002	DO	n/a	Entire reservoir
2004	DO	0199A	Entire reservoir
2006	DO	0199A_01	Entire reservoir
2008	DO	0199A_01	Entire reservoir

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Palo Duro Reservoir:

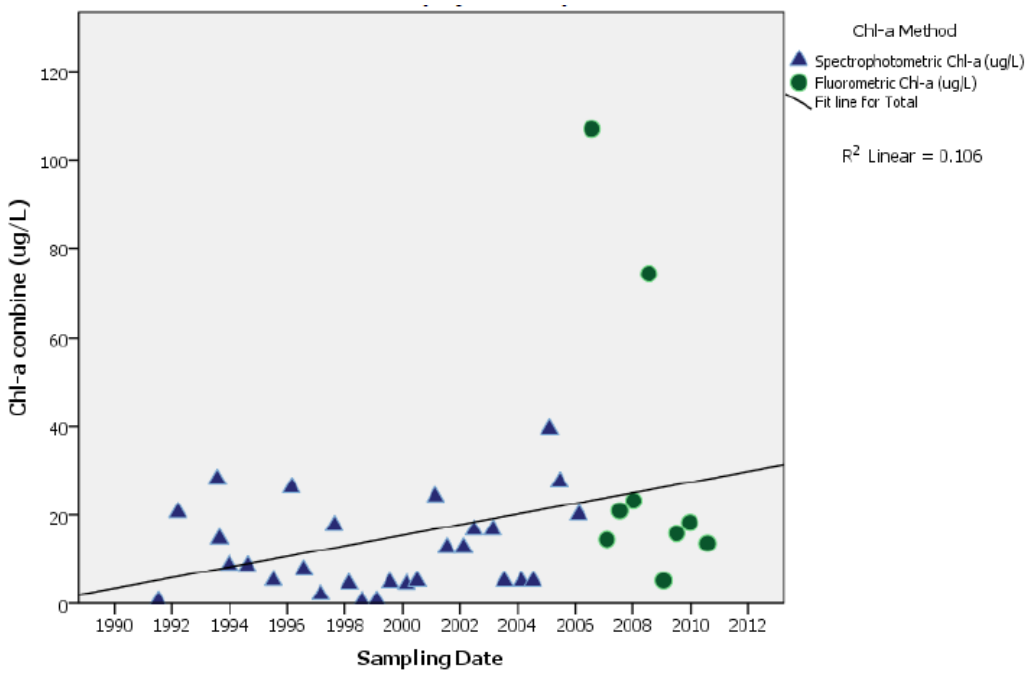
Year	Parameter	Assessment Unit	Assessment Unit Description
2006	NH3-N	0199A_01	Entire reservoir
2008	NH3-N	0199A_01	Entire reservoir
2010	NH3-N	0199A_01	Entire water body
2010	OP	0199A_01	Entire water body
2010	TP	0199A_01	Entire water body

Treated Drinking Water Chemical Data: For facilities using source water from Palo Duro Reservoir, TCEQ did not report finding any exceedances of SDWA MCLs for any disinfection byproducts or nitrate in supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Palo Duro Reservoir was not sampled as part of the 2007 NLA.

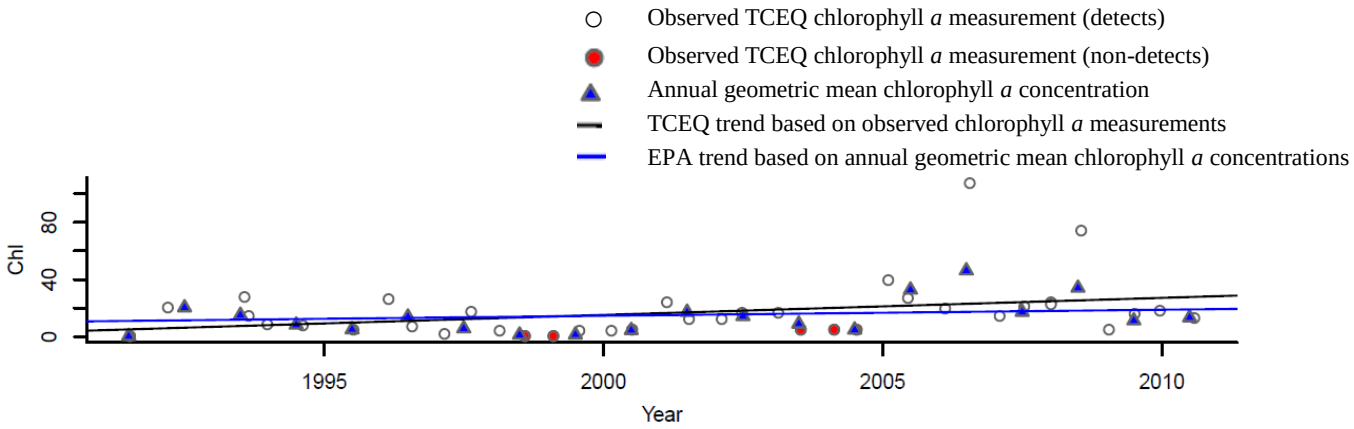
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 37 chlorophyll *a* measurements collected from Palo Duro Reservoir between 1991 and 2010 (see Figure 111). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Palo Duro Reservoir. Based upon the supporting information provided by TCEQ, a shift in methodology does appear to have occurred for this dataset in 2006 (all data after 2006 was collected using the fluorometric method rather than the spectrophotometric method). Twenty-eight chlorophyll *a* measurements were made using the spectrophotometric method, with 7 of these measurements (25%) being reported as less than the minimum reporting limits. Nine measurements were made using the fluorometric method, with none of these measurements (0%) being reported as less than the minimum reporting limits. When TCEQ analyzed trends for each of these datasets separately, neither the chlorophyll *a* data collected using the spectrophotometric method nor the chlorophyll *a* data collected using the fluorometric method showed a statistically significant increasing trend.

Figure 111. Chlorophyll *a* Trend for Palo Duro Reservoir Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Palo Duro Reservoir based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 112). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Palo Duro Reservoir, the magnitude of the slope of this increasing trend was very high, relatively speaking, at 0.421 µg/L chlorophyll *a*/year.

Figure 112. Chlorophyll *a* Trends for Palo Duro Reservoir Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Palo Duro Reservoir was not included in TCEQ's report titled *Trophic Classification of Texas Reservoirs*.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Palo Duro Reservoir, the chlorophyll *a* criterion is below 30 µg/L but 9% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Palo Duro Reservoir, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is not satisfied in the case of Palo Duro Reservoir. Trophic state classification information was not available for Palo Duro Reservoir. Reservoir-specific data and information described above indicates a very high rate of chlorophyll *a* accumulation, relatively speaking, based on EPA's trend analysis (slope = 0.421 µg/L chlorophyll *a*/year) and an increasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. TCEQ identified five CWA §303(d) listings for DO for Palo Duro Reservoir, as well as five concerns for nutrients (NH3-N, OP, and TP) in Palo Duro Reservoir that were repeating. Further, 9% of the measurements in the underlying chlorophyll *a* dataset available for Palo Duro Reservoir were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is not satisfied in the case of Palo Duro Reservoir, EPA strongly considered the very high rate of chlorophyll *a* accumulation, relatively speaking, based on EPA's trend analysis (slope = 0.421 µg/L chlorophyll *a*/year) in combination with TCEQ's identification of five nutrient concerns that were repeating. These two information sources indicate both the presence of nutrients in concentrations of concern to TCEQ and a biological response in the form of a very high chlorophyll *a* accumulation rate. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 21.73 µg/L applicable to Palo Duro Reservoir is not protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA disapproves this reservoir-specific chlorophyll *a* criterion.

57. <u>Lake Granbury, Segment 1205, Chlorophyll *a* Criterion 22.16 µg/L (Disapproved)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 57 measurements collected between between June 12, 1990, and September 4, 2008. Of these 57 measurements, 7 were considered to be outliers because they had values greater than

43.4 µg/L. So, the criterion was derived using a final dataset consisting of 50 chlorophyll *a* measurements collected between between June 12, 1990, and September 4, 2008, all of which were equal to or below 35.5 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Lake Granbury.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Lake Granbury:

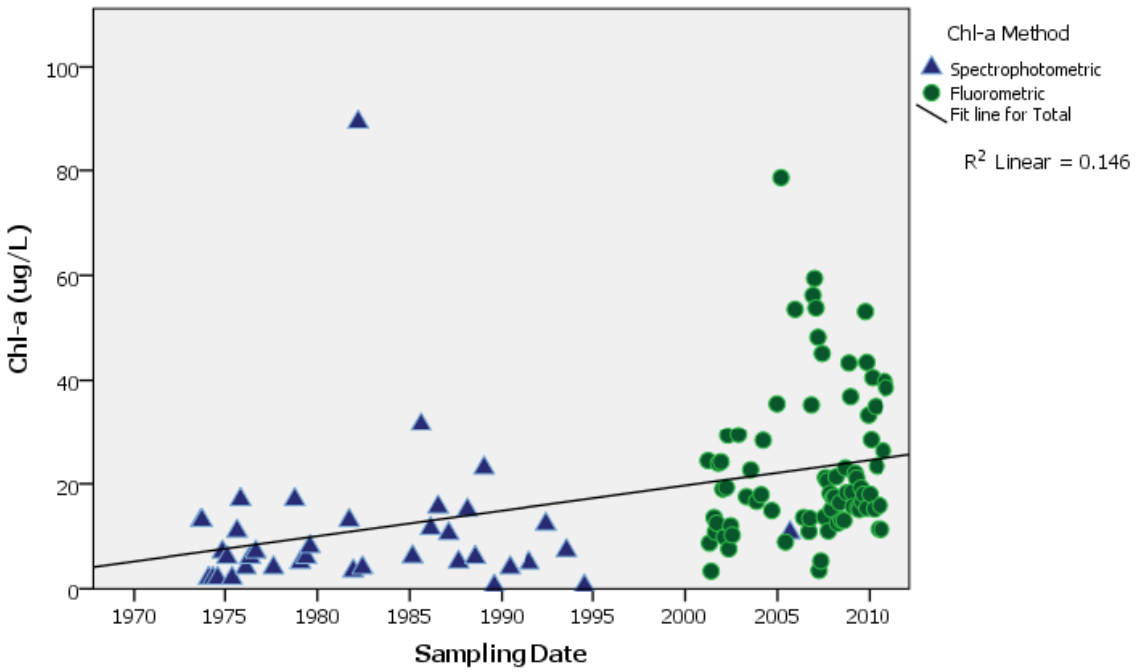
Year	Parameter	Assessment Unit	Assessment Unit Description
2010	Chl-a	1205_02	Portion of lake adjacent to the City of Oak Trail Shores
2010	Chl-a	1205_03	Portion of lake adjacent to the City of Granbury
2010	Chl-a	1205_05	Downstream portion of lake

Treated Drinking Water Chemical Data: For facilities using source water from Lake Granbury, TCEQ did not report finding any exceedances of SDWA MCLs for any disinfection byproducts or nitrate in supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Lake Granbury was not sampled as part of the 2007 NLA.

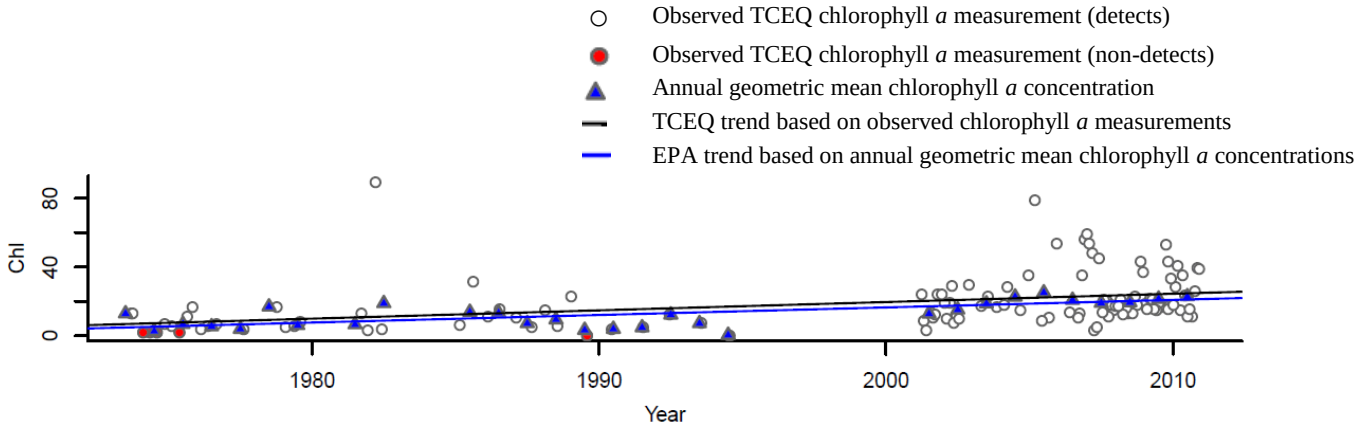
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 117 chlorophyll *a* measurements collected from Lake Granbury between 1973 and 2010 (see Figure 113). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Lake Granbury. Based upon the supporting information provided by TCEQ, a shift in methodology does appear to have occurred for this dataset in 2001 (most data after 2001 was collected using the fluorometric method rather than the spectrophotometric method). Thirty-eight chlorophyll *a* measurements were made using the spectrophotometric method, with 6 of these measurements (~16%) being reported as less than the minimum reporting limits. Seventy-nine measurements were made using the fluorometric method, with none of these measurements (0%) being reported as less than the minimum reporting limits. When TCEQ analyzed trends for each of these datasets separately, neither the chlorophyll *a* data collected using the spectrophotometric method nor the chlorophyll *a* data collected using the fluorometric method showed a statistically significant increasing trend.

Figure 113. Chlorophyll *a* Trend for Lake Granbury Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Lake Granbury based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 114). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Lake Granbury, the magnitude of the slope of this increasing trend was very high, relatively speaking, at 0.439 µg/L chlorophyll *a*/year.

Figure 114. Chlorophyll *a* Trends for Lake Granbury Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Lake Granbury was not included in TCEQ's report titled *Trophic Classification of Texas Reservoirs*.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix

and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Lake Granbury, the chlorophyll *a* criterion is below 30 µg/L but 14% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Lake Granbury, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is not satisfied in the case of Lake Granbury. Trophic state classification information was not available for Lake Granbury. Reservoir-specific data and information described above indicates a very high rate of chlorophyll *a* accumulation, relatively speaking, based on EPA's trend analysis (slope = 0.439 µg/L chlorophyll *a*/year) and an increasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. TCEQ did not identify any CWA §303(d) listings for pH or DO for Lake Granbury. While TCEQ did not identify any nutrient concerns in Lake Granbury, TCEQ did identify three concerns for chlorophyll *a* in the 2010 reporting cycle. 14% of the measurements in the underlying chlorophyll *a* dataset available for Lake Granbury were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is not satisfied in the case of Lake Granbury, EPA strongly considered this last information source. With 14% of the measurements in the underlying chlorophyll *a* dataset available for Lake Granbury being greater than 30 µg/L, EPA is concerned that the chlorophyll *a* criterion (which is derived and expressed as a long-term central tendency), is not likely to protect designated uses from the effects of high instantaneous chlorophyll *a* concentrations (such as nuisance blooms, toxic cyanobacteria and toxin production, taste and odor compound production, and disinfection byproduct production). Based on the above information, EPA concludes that the chlorophyll *a* criterion of 22.16 µg/L applicable to Lake Granbury is not protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA disapproves this reservoir-specific chlorophyll *a* criterion.

58. Bardwell Reservoir, Segment 0815, Chlorophyll *a* Criterion 22.84 µg/L (Disapproved)

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 36 measurements collected between between June 25, 1990, and August 21, 2008. Of these 36 measurements, one was considered to be an outlier because it had a value greater than 46.245 µg/L. So, the criterion was derived using a final dataset consisting of 35 chlorophyll *a* measurements collected between between June 25, 1990, and August 21, 2008, all of which were equal to or below 34.7 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Bardwell Reservoir.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Bardwell Reservoir:

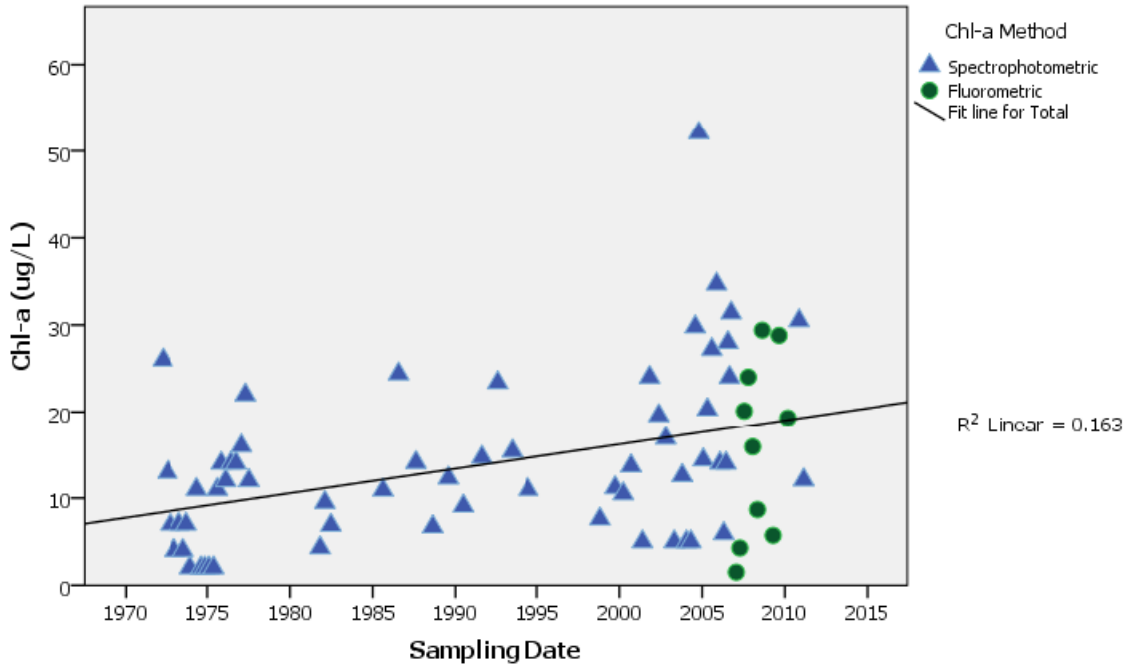
Year	Parameter	Assessment Unit	Assessment Unit Description
2006	NO3-N	0815_01	Entire reservoir
2008	NO3-N	0815_01	Entire reservoir
2010	NO3-N	0815_01	Entire reservoir

Treated Drinking Water Chemical Data: For facilities using source water from Bardwell Reservoir, TCEQ did not report finding any exceedances of SDWA MCLs for any disinfection byproducts or nitrate in supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Bardwell Reservoir was not sampled as part of the 2007 NLA.

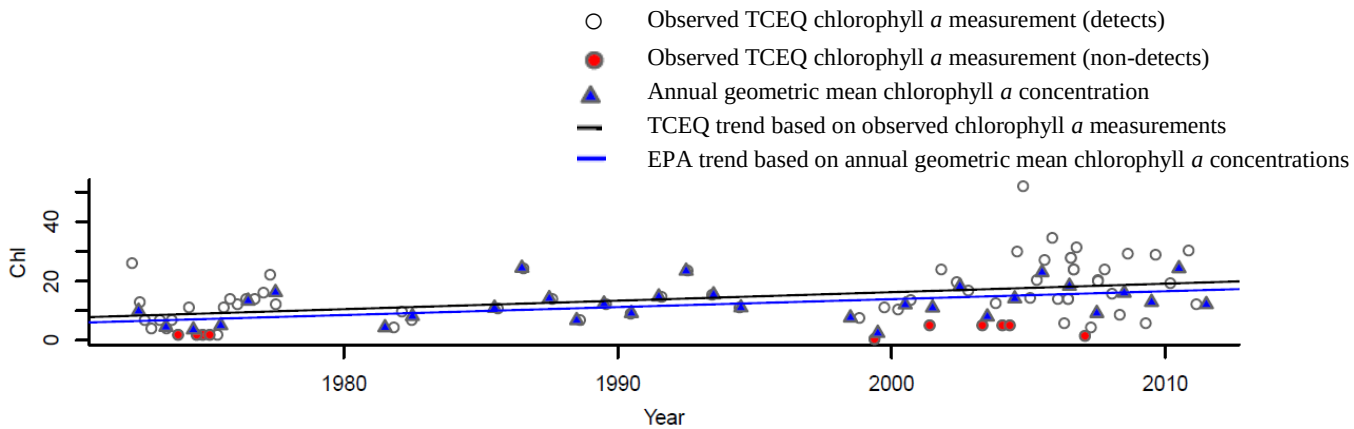
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 70 chlorophyll *a* measurements collected from Bardwell Reservoir between 1972 and 2011 (see Figure 115). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Lake Waxahachie. Based upon the supporting information provided by TCEQ, a shift in methodology does appear to have occurred for this dataset in 2006 (with some data after 2006 being collected using the fluorometric method rather than the spectrophotometric method). Fifty-nine chlorophyll *a* measurements were made using the spectrophotometric method, with 8 of these measurements (~14%) being reported as less than the minimum reporting limits. Eleven measurements were made using the fluorometric method, with 1 of these measurements (~9%) being reported as less than the minimum reporting limits. When TCEQ analyzed trends for each of these datasets separately, the chlorophyll *a* data collected using the fluorometic method did not show a statistically significant increasing trend, while the chlorophyll *a* data collected using the spectrophotometric method did show a statistically significant increasing trend. In further analyzing the spectrophotometric method dataset, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) did not affect the statistical significance of this chlorophyll *a* trend to such a degree that the trend became statistically insignificant. Therefore, EPA believes that this increasing trend for Bardwell Reservoir is statistically significant.

Figure 115. Chlorophyll *a* Trend for Bardwell Reservoir Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Bardwell Reservoir based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 116). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Bardwell Reservoir, the magnitude of the slope of this increasing trend was relatively high at 0.268 µg/L chlorophyll *a*/year.

Figure 116. Chlorophyll *a* Trends for Bardwell Reservoir Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Bardwell Reservoir was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Bardwell Reservoir between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 58.34 was determined for the 2010 reporting cycle for Bardwell Reservoir. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 6.04 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Bardwell Reservoir shifted from a eutrophic classification for the 2000 reporting cycle to a hypereutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Bardwell Reservoir, the chlorophyll *a* criterion is below 30 µg/L but 4% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Bardwell Reservoir, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is not satisfied in the case of Bardwell Reservoir. Reservoir-specific data and information described above indicates a eutrophic classification for Bardwell Reservoir in the 2000 reporting cycle with a shift to a hypereutrophic classification in the 2010 reporting cycle. Reservoir-specific data and information described above indicates a relatively high rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.268 µg/L chlorophyll *a*/year) and a statistically significant increasing trend in chlorophyll *a* concentration based on EPA's review of TCEQ's trend

analysis. TCEQ did not identify any CWA §303(d) listings for pH or DO for Bardwell Reservoir. However, TCEQ did identify three concerns for nutrients (NO3-N) in Bardwell Reservoir that were repeating. 4% of the measurements in the underlying chlorophyll *a* dataset available for Bardwell Reservoir were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is not satisfied in the case of Bardwell Reservoir, EPA not only strongly considered the shift to a hypereutrophic classification in the 2010 reporting cycle, but also strongly considered the relatively high rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.268 µg/L chlorophyll *a*/year) in combination with TCEQ's identification of three nutrient concerns that were repeating. These latter two information sources indicate both the presence of nutrients in concentrations of concern to TCEQ and a biological response in the form of a relatively high chlorophyll *a* accumulation rate. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 22.84 µg/L applicable to Bardwell Reservoir is not protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA disapproves this reservoir-specific chlorophyll *a* criterion.

59. Lake Livingston, Segment 0803, Chlorophyll *a* Criterion 22.96 µg/L (Disapproved)

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 118 measurements collected between between January 23, 1990, and December 18, 2006. Of these 118 measurements, 1 was considered to be an outlier because it had a value greater than 44.8375 µg/L. So, the criterion was derived using a final dataset consisting of 117 chlorophyll *a* measurements collected between between January 23, 1990, and December 18, 2006, all of which were equal to or below 44 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for pH and DO listings in the 2000 through 2010 reporting cycles, the following 303(d) listings were identified for Lake Livingston:

Year	Parameter	Assessment Unit	Assessment Unit Description
2000	DO	n/a	5,120 acres in the dam area
2002	DO	n/a	Lowermost portion of reservoir, adjacent to dam
2004	DO	n/a	Lowermost portion of reservoir, adjacent to dam
2006	DO	0803_01	Lowermost portion of reservoir, adjacent to dam
2008	pH	0803_01	Lowermost portion of reservoir, adjacent to dam
2010	pH	0803_01	Lowermost portion of reservoir, adjacent to dam
2002	DO	n/a	Lower portion of reservoir, East Wolf Creek
2004	DO	n/a	Lower portion of reservoir, East Wolf Creek
2006	DO	0803_02	Lower portion of reservoir, East Wolf Creek
2002	DO	n/a	Lower portion of reservoir, East Willow Springs
2004	DO	n/a	Lower portion of reservoir, East Willow Springs
2006	DO	0803_03	Lower portion of reservoir, East Willow Springs
2002	DO	n/a	Middle portion of reservoir, East Pointblank
2004	DO	n/a	Middle portion of reservoir, East Pointblank
2006	DO	0804_04	Middle portion of reservoir, East Pointblank
2008	pH	0803_06	Middle portion of reservoir, centering on US 190
2010	pH	0803_06	Middle portion of reservoir, centering on US 190
2002	DO	n/a	Cove off upper portion of reservoir, East Trinity
2004	DO	n/a	Cove off upper portion of reservoir, East Trinity
2006	DO	0803_08	Cove off upper portion of reservoir, East Trinity
2004	pH	n/a	Cove off upper portion of reservoir, East Trinity
2000	DO	n/a	5,120 acres in the lower-middle lake
2000	DO	n/a	5,120 acres in the middle lake
2000	DO	n/a	5,120 acres in the upper portion at SH 19

Year	Parameter	Assessment Unit	Assessment Unit Description
2000	high pH	n/a	5,120 acres near the mouth of Kickapoo Creek
2000	DO	n/a	5,120 acres near the mouth of Kickapoo Creek Cove
2000	DO	n/a	5,120 acres near the mouth of White Rock Creek Cove
2002	DO	n/a	Middle portion of reservoir, downstream of Kickapoo Creek
2002	DO	n/a	Upper portion of reservoir, centering on SH 19
2002	DO	n/a	Upper portion of reservoir, west of Carlisle
2002	high pH	n/a	Upper portion of reservoir, west of Carlisle
2004	high pH	n/a	Upper portion of reservoir, west of Carlisle

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Lake Livingston:

Year	Parameter	Assessment Unit	Assessment Unit Description
2006	NO3-N	0803_01	Lowermost portion of reservoir, adjacent to dam
2008	NO3-N	0803_01	Lowermost portion of reservoir, adjacent to dam
2010	NO3-N	0803_01	Lowermost portion of reservoir, adjacent to dam
2006	OP	0803_01	Lowermost portion of reservoir, adjacent to dam
2008	OP	0803_01	Lowermost portion of reservoir, adjacent to dam
2010	OP	0803_01	Lowermost portion of reservoir, adjacent to dam
2010	DO	0803_04	Middle portion of reservoir, East Pointblank
2006	NO3-N	0803_04	Middle portion of reservoir, East Pointblank
2008	NO3-N	0803_04	Middle portion of reservoir, East Pointblank
2010	NO3-N	0803_04	Middle portion of reservoir, East Pointblank
2006	OP	0803_04	Middle portion of reservoir, East Pointblank
2008	OP	0803_04	Middle portion of reservoir, East Pointblank
2010	OP	0803_04	Middle portion of reservoir, East Pointblank
2006	Chl-a	0803_05	Middle portion of reservoir, downstream of Kickapoo Creek
2008	Chl-a	0803_05	Middle portion of reservoir, downstream of Kickapoo Creek
2010	Chl-a	0803_05	Middle portion of reservoir, downstream of Kickapoo Creek
2006	OP	0803_05	Middle portion of reservoir, downstream of Kickapoo Creek
2008	OP	0803_05	Middle portion of reservoir, downstream of Kickapoo Creek
2010	OP	0803_05	Middle portion of reservoir, downstream of Kickapoo Creek
2008	TP	0803_05	Middle portion of reservoir, downstream of Kickapoo Creek
2010	TP	0803_05	Middle portion of reservoir, downstream of Kickapoo Creek
2006	Chl-a	0803_06	Middle portion of reservoir, centering on US 190
2008	Chl-a	0803_06	Middle portion of reservoir, centering on US 190
2010	Chl-a	0803_06	Middle portion of reservoir, centering on US 190
2006	NO3-N	0803_06	Middle portion of reservoir, centering on US 190
2008	NO3-N	0803_06	Middle portion of reservoir, centering on US 190
2010	NO3-N	0803_06	Middle portion of reservoir, centering on US 190
2006	OP	0803_06	Middle portion of reservoir, centering on US 190
2008	OP	0803_06	Middle portion of reservoir, centering on US 190
2010	OP	0803_06	Middle portion of reservoir, centering on US 190
2006	TP	0803_06	Middle portion of reservoir, centering on US 190
2008	TP	0803_06	Middle portion of reservoir, centering on US 190
2010	TP	0803_06	Middle portion of reservoir, centering on US 190
2006	Chl-a	0803_07	Upper portion of reservoir, west of Carlisle
2008	Chl-a	0803_07	Upper portion of reservoir, west of Carlisle
2010	Chl-a	0803_07	Upper portion of reservoir, west of Carlisle
2006	NO3-N	0803_07	Upper portion of reservoir, west of Carlisle

Year	Parameter	Assessment Unit	Assessment Unit Description
2008	NO3-N	0803_07	Upper portion of reservoir, west of Carlisle
2010	NO3-N	0803_07	Upper portion of reservoir, west of Carlisle
2006	OP	0803_07	Upper portion of reservoir, west of Carlisle
2008	OP	0803_07	Upper portion of reservoir, west of Carlisle
2010	OP	0803_07	Upper portion of reservoir, west of Carlisle
2008	pH	0803_07	Upper portion of reservoir, west of Carlisle
2006	TP	0803_07	Upper portion of reservoir, west of Carlisle
2008	TP	0803_07	Upper portion of reservoir, west of Carlisle
2010	TP	0803_07	Upper portion of reservoir, west of Carlisle
2006	DO	0803_08	Cove off upper portion of reservoir, East Trinity
2008	DO	0803_08	Cove off upper portion of reservoir, East Trinity
2010	DO	0803_08	Cove off upper portion of reservoir, East Trinity
2006	NO3-N	0803_08	Cove off upper portion of reservoir, East Trinity
2008	NO3-N	0803_08	Cove off upper portion of reservoir, East Trinity
2010	NO3-N	0803_08	Cove off upper portion of reservoir, East Trinity
2006	OP	0803_08	Cove off upper portion of reservoir, East Trinity
2008	OP	0803_08	Cove off upper portion of reservoir, East Trinity
2010	OP	0803_08	Cove off upper portion of reservoir, East Trinity
2006	DO	0803_09	West Carolina Creek cove, off upper portion of reservoir
2008	DO	0803_09	West Carolina Creek cove, off upper portion of reservoir
2010	DO	0803_09	West Carolina Creek cove, off upper portion of reservoir
2006	DO	0803_10	Upper portion of reservoir, centering on SH 19
2008	DO	0803_10	Upper portion of reservoir, centering on SH 19
2010	DO	0803_10	Upper portion of reservoir, centering on SH 19
2006	NO3-N	0803_10	Upper portion of reservoir, centering on SH 19
2008	NO3-N	0803_10	Upper portion of reservoir, centering on SH 19
2010	NO3-N	0803_10	Upper portion of reservoir, centering on SH 19
2008	OP	0803_10	Upper portion of reservoir, centering on SH 19
2010	OP	0803_10	Upper portion of reservoir, centering on SH 19
2006	TP	0803_10	Upper portion of reservoir, centering on SH 19
2008	TP	0803_10	Upper portion of reservoir, centering on SH 19
2010	TP	0803_10	Upper portion of reservoir, centering on SH 19
2006	NO3-N	0803_11	Riverine portion of reservoir, centering on SH 21
2008	NO3-N	0803_11	Riverine portion of reservoir, centering on SH 21
2010	NO3-N	0803_11	Riverine portion of reservoir, centering on SH 21
2006	OP	0803_11	Riverine portion of reservoir, centering on SH 21
2008	OP	0803_11	Riverine portion of reservoir, centering on SH 21
2010	OP	0803_11	Riverine portion of reservoir, centering on SH 21
2006	TP	0803_11	Riverine portion of reservoir, centering on SH 21
2008	TP	0803_11	Riverine portion of reservoir, centering on SH 21
2010	TP	0803_11	Riverine portion of reservoir, centering on SH 21

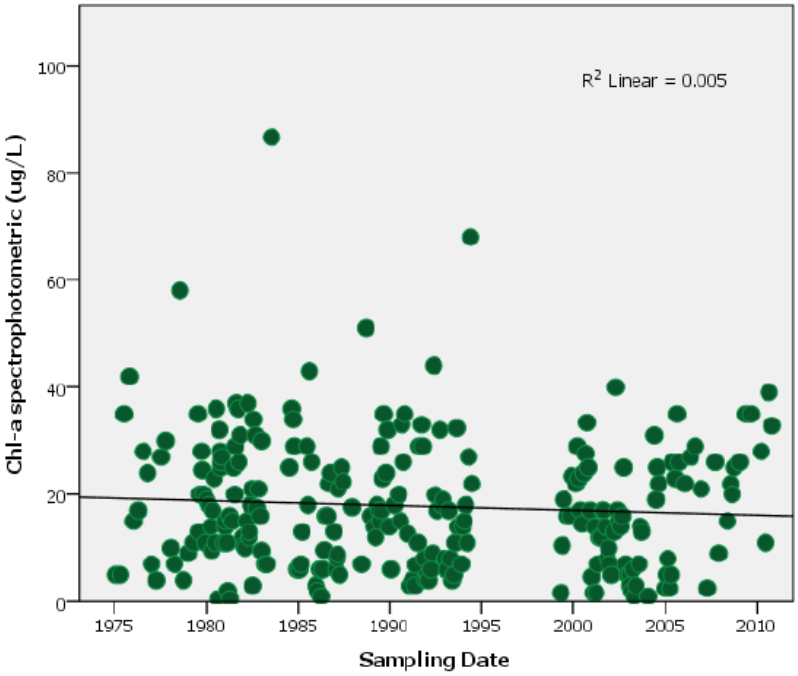
Treated Drinking Water Chemical Data: For facilities using source water from Lake Livingston, TCEQ did not report finding any exceedances of SDWA MCLs for any disinfection byproducts or nitrate in supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Lake Livingston was sampled one time as part of the 2007 NLA. The chlorophyll *a* concentration measured during sampling was 20.64 µg/L, indicating a moderate risk of exposure based on the chlorophyll *a* thresholds used in the NLA study. The microcystin concentration during sampling was below the reporting limit of 0.1 µg/L, indicating a low risk of exposure based on the microcystin thresholds used in the NLA study. The cyanobacteria cell count during sampling was less

than 20,000 cells per milliliter, indicating a low risk of exposure based on the cyanobacteria thresholds used in the NLA study.

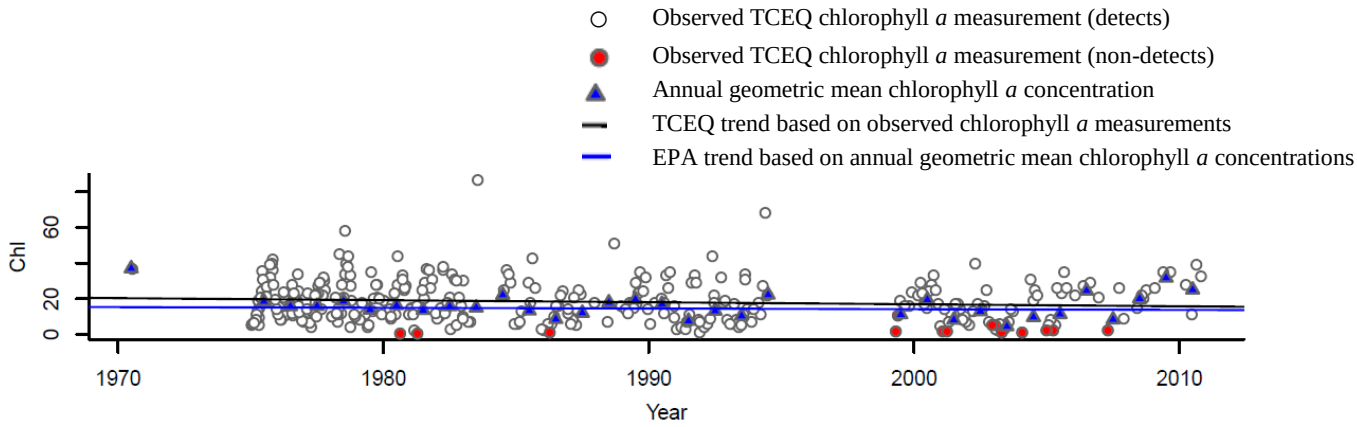
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ did not identify any statistically significant increasing trends in chlorophyll *a* concentrations for Lake Livingston (see Figure 117).

Figure 117. Chlorophyll *a* Trend for Lake Livingston Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Lake Livingston based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 118). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Lake Livingston, the trend was decreasing with a slope magnitude of -0.040 µg/L chlorophyll *a*/year.

Figure 118. Chlorophyll *a* Trends for Lake Livingston Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Lake Livingston was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Lake Livingston between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 57.54 was determined for the 2010 reporting cycle for Lake Livingston. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 1.59 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Lake Livingston was hypereutrophic for both the 2000 and 2010 reporting cycles.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Lake Livingston, the chlorophyll *a* criterion is below 30 µg/L but 13% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Lake Livingston, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is not satisfied in the case of Lake Livingston. Though reservoir-specific data and information described above indicates a decreasing rate of chlorophyll *a* accumulation, based on EPA's trend analysis (slope = -0.040 µg/L chlorophyll *a*/year) and a decreasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis, EPA notes that reservoir-specific data and information described above indicates a hypereutrophic classification for Lake Livingston in both the 2000 and 2010 reporting cycles. TCEQ also identified 32 CWA §303(d) listings for pH and DO for Lake Livingston in the 2000 through 2010 reporting cycles. TCEQ also identified 20 concerns for chlorophyll *a*, pH and DO in Lake Livingston in the 2006 through 2010 reporting cycles. Additionally, TCEQ identified 58 concerns for nutrients (NO3-N, OP, and TP) in Lake Livingston that were repeating. 2007 NLA data for Lake Livingston indicated a moderate risk of exposure based on chlorophyll *a* thresholds and a low risk of exposure based on based on microcystin and cyanobacteria thresholds. Further, 13% of the measurements in the underlying chlorophyll *a* dataset available for Lake Livingston were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is not satisfied in the case of Lake Livingston, EPA not only strongly considered

the reservoir's hypereutrophic classification in the 2000 and 2010 reporting cycles, but also strongly considered the fact that 13% of the measurements in the underlying chlorophyll *a* dataset available for Lake Livingston were greater than 30 µg/L. With this being the case, EPA is concerned that the chlorophyll *a* criterion (which is derived and expressed as a long-term central tendency), is not likely to protect designated uses from the effects of high instantaneous chlorophyll *a* concentrations (such as nuisance blooms, toxic cyanobacteria and toxin production, taste and odor compound production, and disinfection byproduct production). Based on the above information, EPA concludes that the chlorophyll *a* criterion of 22.96 µg/L applicable to Lake Livingston is not protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA disapproves this reservoir-specific chlorophyll *a* criterion.

60. <u>Waco Lake, Segment 1225, Chlorophyll *a* Criterion 23.16 µg/L (Disapproved)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 120 measurements collected between between July 16, 1990, and October 13, 2008. Of these 120 measurements, none were considered to be outliers because none had values greater than 42.88375 µg/L. So, the criterion was derived using a final dataset consisting of 120 chlorophyll *a* measurements collected between between July 16, 1990, and October 13, 2008, all of which were equal to or below 41.2 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Waco Lake.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Waco Lake:

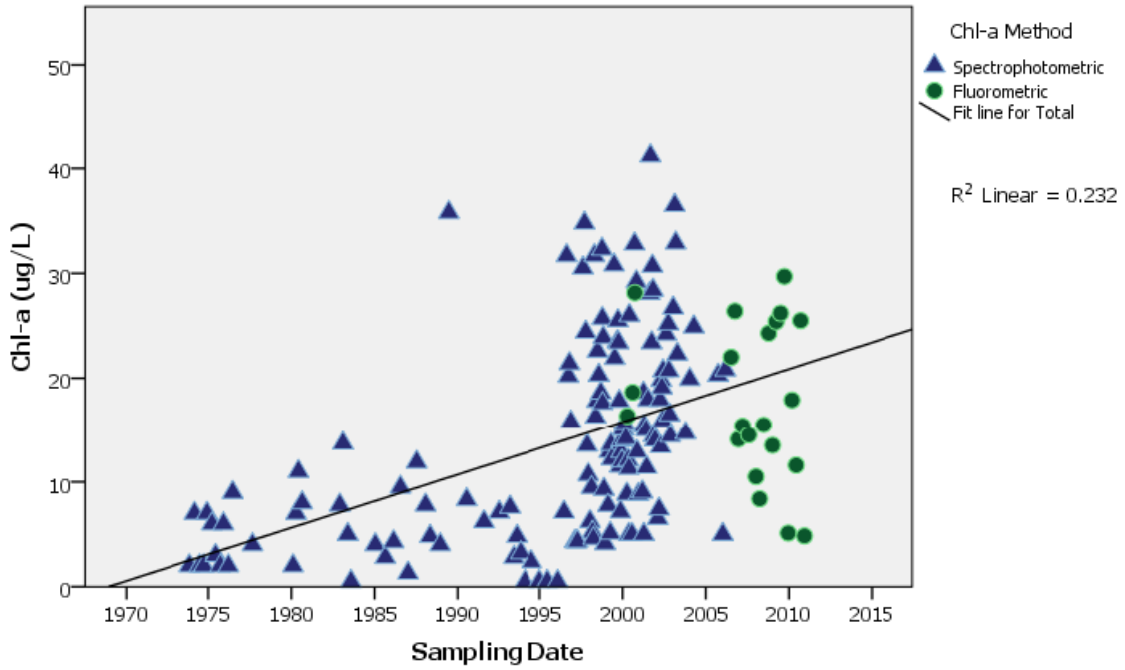
Year	Parameter	Assessment Unit	Assessment Unit Description
2006	Chl-a	1225_01	North Bosque River arm of lake
2008	Chl-a	1225_01	North Bosque River arm of lake
2006	NO3-N	1225_01	North Bosque River arm of lake
2008	NO3-N	1225_01	North Bosque River arm of lake
2010	NO3-N	1225_01	North Bosque River arm of lake
2006	NO3-N	1225_02	Portion of lake near dam
2008	NO3-N	1225_02	Portion of lake near dam
2010	NO3-N	1225_02	Portion of lake near dam
2006	Chl-a	1225_03	Middle/South Bosque River arm of lake
2008	Chl-a	1225_03	Middle/South Bosque River arm of lake
2006	NO3-N	1225_03	Middle/South Bosque River arm of lake
2008	NO3-N	1225_03	Middle/South Bosque River arm of lake
2010	NO3-N	1225_03	Middle/South Bosque River arm of lake

Treated Drinking Water Chemical Data: For facilities using source water from Waco Lake, TCEQ did not report finding any exceedances of SDWA MCLs for any disinfection byproducts or nitrate in supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Waco Lake was not sampled as part of the 2007 NLA.

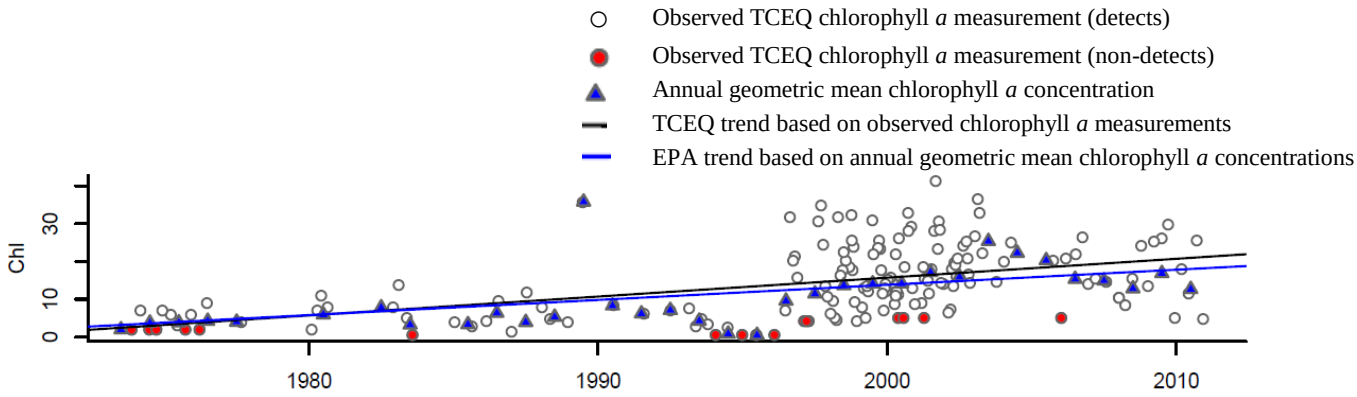
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 158 chlorophyll *a* measurements collected from Waco Lake between 1973 and 2010 (see Figure 119). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Waco Lake. Based upon the supporting information provided by TCEQ, a shift in methodology does appear to have occurred for this dataset in 2006 (with most data after 2006 being collected using the fluorometric method rather than the spectrophotometric method). One hundred and thirty-eight chlorophyll *a* measurements were made using the spectrophotometric method, with 17 of these measurements (~12%) being reported as less than the minimum reporting limits. Twenty-one measurements were made using the fluorometric method, with none of these measurements (0%) being reported as less than the minimum reporting limits. When TCEQ analyzed trends for each of these datasets separately, the chlorophyll *a* data collected using the fluorometic method did not show a statistically significant increasing trend, while the chlorophyll *a* data collected using the spectrophotometric method did show a statistically significant increasing trend. In further analyzing the spectrophotometric method dataset, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) did not affect the statistical significance of this chlorophyll *a* trend to such a degree that the trend became statistically insignificant. Therefore, EPA believes that this increasing trend for Waco Lake is statistically significant.

Figure 119. Chlorophyll *a* Trend for Waco Lake Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Waco Lake based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 120). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Waco Lake, the magnitude of the slope of this increasing trend was very high, relatively speaking, at 0.400 µg/L chlorophyll *a*/year.

Figure 120. Chlorophyll *a* Trends for Waco Lake Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Waco Lake was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Waco Lake between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 54.02 was determined for the 2010 reporting cycle for Waco Lake. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 10.75 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Waco Lake shifted from a mesotrophic classification for the 2000 reporting cycle to a eutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Waco Lake, the chlorophyll *a* criterion is below 30 µg/L but 8% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Waco Lake, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is not satisfied in the case of Waco Lake. Reservoir-specific data and information described above indicates a mesotrophic classification for Waco Lake in the 2000 reporting cycle with a shift to a eutrophic classification in the 2010 reporting cycle. Reservoir-specific data and information described above indicates a very high rate of chlorophyll *a* accumulation, relatively speaking, based on EPA's trend analysis (slope = 0.400 µg/L chlorophyll *a*/year) and a statistically significant increasing trend in chlorophyll *a* concentration based on EPA's review of TCEQ's trend analysis. TCEQ did not identify any CWA §303(d) listings for pH or DO for Waco Lake. However, TCEQ did identify four concerns for chlorophyll *a* in Waco Lake in the 2006 through 2008 reporting cycles, as well as nine concerns for nutrients (NO3-N) in Waco Lake that were repeating. 8% of the measurements in the underlying chlorophyll *a* dataset available for Waco Lake were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is not satisfied in the case of Waco Lake, EPA strongly considered the very high rate of chlorophyll *a* accumulation, relatively speaking, based on EPA's trend analysis (slope = 0.400 µg/L chlorophyll *a*/year) in combination with TCEQ's identification of nine nutrient concerns that were repeating. These two information sources indicate both the presence of

nutrients in concentrations of concern to TCEQ and a biological response in the form of a relatively high chlorophyll *a* accumulation rate. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 23.16 µg/L applicable to Waco Lake is not protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA disapproves this reservoir-specific chlorophyll *a* criterion.

61. <u>Brady Creek Reservoir, Segment 1416, Chlorophyll *a* Criterion 24.15 µg/L (Disapproved)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 38 measurements collected between between August 2, 1990, and October 29, 2008. Of these 38 measurements, 1 was considered to be an outlier because it had a value greater than 41.3 µg/L. So, the criterion was derived using a final dataset consisting of 37 chlorophyll *a* measurements collected between between August 2, 1990, and October 29, 2008, all of which were equal to or below 36.6 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Brady Creek Reservoir.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, no water quality concerns for any nutrient or nutrient enrichment-related indicators were identified for Brady Creek Reservoir.

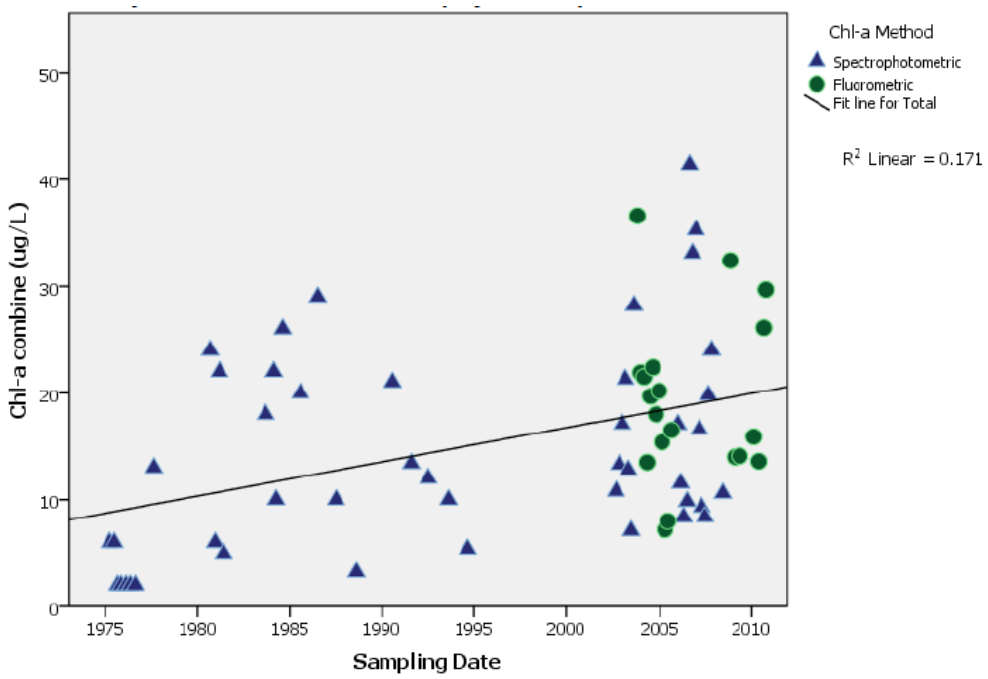
Treated Drinking Water Chemical Data: In supporting documentation provided to EPA on February 24, 2012, TCEQ identified one facility using source water from Brady Creek Reservoir which reported periodic occurrences of total trihalomethanes above the SDWA MCL.

2007 National Lakes Assessment Data: Brady Creek Reservoir was not sampled as part of the 2007 NLA.

TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 64 chlorophyll *a* measurements collected from Brady Creek Reservoir between 1975 and 2010 (see Figure 121). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Brady Creek Reservoir. Based upon the supporting information provided by TCEQ, a shift in methodology does appear to have occurred for this dataset in 2003 (with some data after 2003 being collected using the fluorometric method rather than the spectrophotometric method). Forty-five chlorophyll *a* measurements were made using the spectrophotometric method, with 5 of these measurements (~11%) being reported as less than the minimum reporting limits. Nineteen measurements were made using the fluorometric method, with none of these measurements (0%) being reported as less than the minimum reporting limits. When TCEQ analyzed trends for each of these datasets separately, the chlorophyll *a* data collected using the fluorometic method did not show a statistically significant increasing trend, while the chlorophyll *a* data collected using the spectrophotometric method did show a statistically significant increasing trend. In further analyzing the spectrophotometric method dataset, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) did not affect the statistical significance of this chlorophyll *a* trend to such a degree that the trend became statistically

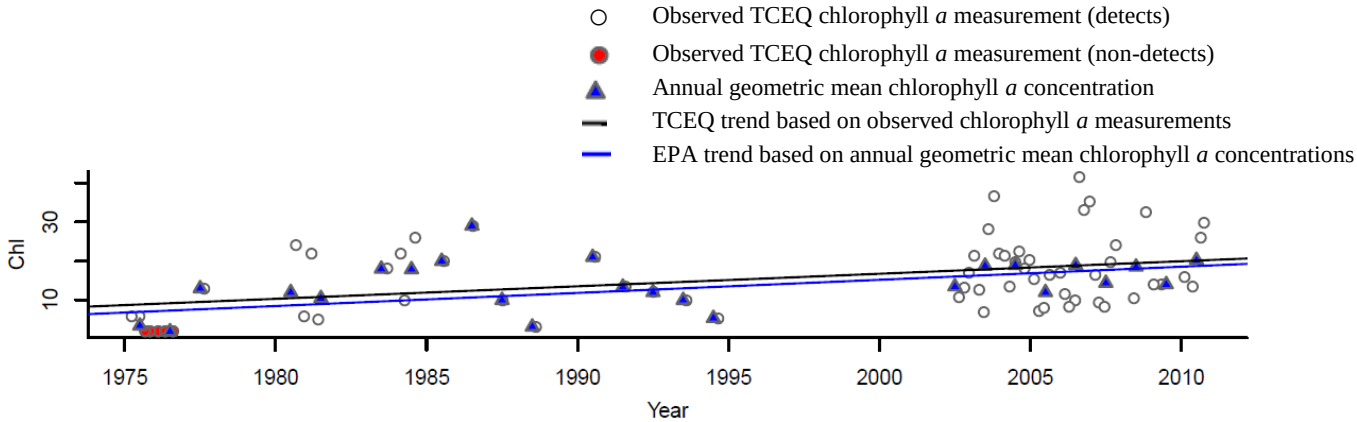
insignificant. Therefore, EPA believes that this increasing trend for Brady Creek Reservoir is statistically significant.

Figure 121. Chlorophyll *a* Trend for Brady Creek Reservoir Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Brady Creek Reservoir based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 122). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Brady Creek Reservoir, the magnitude of the slope of this increasing trend was relatively high at 0.335 µg/L chlorophyll *a*/year.

Figure 122. Chlorophyll *a* Trends for Brady Creek Reservoir Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Brady Creek Reservoir was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010

reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Brady Creek Reservoir between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 58.84 was determined for the 2010 reporting cycle for Brady Creek Reservoir. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 4.48 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Brady Creek Reservoir shifted from a eutrophic classification for the 2000 reporting cycle to a hypereutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Brady Creek Reservoir, the chlorophyll *a* criterion is below 30 µg/L but 9% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Brady Creek Reservoir, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is not satisfied in the case of Brady Creek Reservoir. Reservoir-specific data and information described above indicates a eutrophic classification for Brady Creek Reservoir in the 2000 reporting cycle with a shift to a hypereutrophic classification in the 2010 reporting cycle. Reservoir-specific data and information described above indicates a relatively high rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.335 µg/L chlorophyll *a*/year) and a statistically significant increasing trend in chlorophyll *a* concentration based on EPA's review of TCEQ's trend analysis. TCEQ did not identify any CWA §303(d) listings for pH or DO for Brady Creek Reservoir, nor did it identify any concerns for nutrient or nutrient-enrichment related indicators. However, TCEQ did identify one facility using source water from Brady Creek Reservoir which reported periodic occurrences of total trihalomethanes above the SDWA MCL. 9% of the measurements in the underlying chlorophyll *a* dataset available for Brady Creek Reservoir were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is not satisfied in the case of Brady Creek Reservoir, EPA strongly considered the shift to a hypereutrophic classification in the 2010 reporting cycle, along with the relatively high rate of chlorophyll a accumulation based on EPA's trend analysis (slope = 0.335 µg/L chlorophyll *a*/year) and the MCL exceedances noted above. Based on the above information, EPA concludes that the chlorophyll *a* criterion of 24.15 µg/L applicable to Brady Creek Reservoir is not protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA disapproves this reservoir-specific chlorophyll *a* criterion.

62. <u>Lake Conroe, Segment 1012, Chlorophyll *a* Criterion 24.27 µg/L (Disapproved)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 34 measurements collected between between February 7, 1991, and October 1, 2008. Of these 34 measurements, 2 were considered to be outliers because they had values greater than 40.47375 µg/L. So, the criterion was derived using a final dataset consisting of 32 chlorophyll *a* measurements collected between between February 7, 1991, and October 1, 2008, all of which were equal to or below 34 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Lake Conroe.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Lake Conroe:

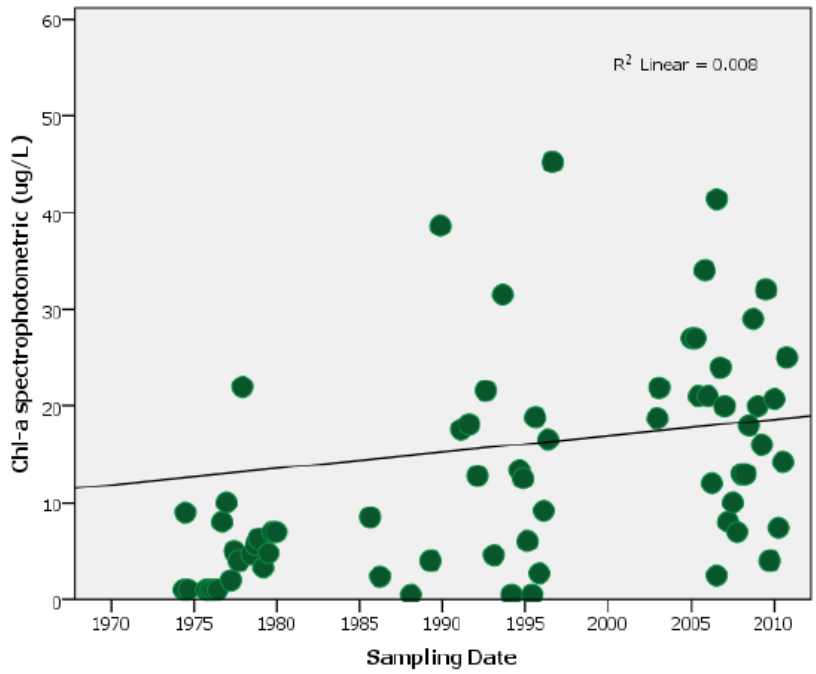
Year	Parameter	Assessment Unit	Assessment Unit Description
2008	Chl-a	1012_03	Lewis Creek arm
2010	Chl-a	1012_03	Lewis Creek arm
2008	Chl-a	1012_04	Caney Creek arm to Hunters Point
2010	Chl-a	1012_04	Caney Creek arm to Hunters Point
2008	Chl-a	1012_05	Johnson Bluff to FM 1097
2010	Chl-a	1012_05	Johnson Bluff to FM 1097
2008	Chl-a	1012_06	Little Lake Creek arm to Walden Estates
2008	Chl-a	1012_07	Lewis Creek arm to Bowspirit Point
2008	Chl-a	1012_11	Walden Estates to dam

Treated Drinking Water Chemical Data: For facilities using source water from Lake Conroe, TCEQ did not report finding any exceedances of SDWA MCLs for any disinfection byproducts or nitrate in supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Lake Conroe was not sampled as part of the 2007 NLA.

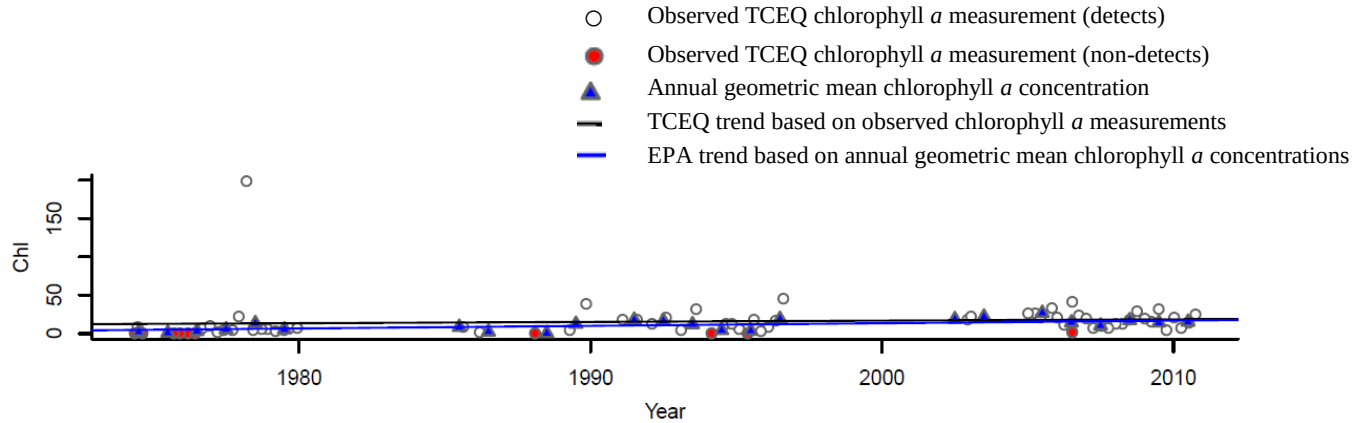
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ did not identify any statistically significant increasing trends in chlorophyll *a* concentrations for Lake Conroe (see Figure 123).

Figure 123. Chlorophyll *a* Trend for Lake Conroe Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Lake Conroe based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 124). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Lake Conroe, the magnitude of the slope of this increasing trend was relatively high at 0.340 µg/L chlorophyll *a*/year.

Figure 124. Chlorophyll *a* Trends for Lake Conroe Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Lake Conroe was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Lake Conroe between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 58.9 was determined for the 2010 reporting cycle for Lake Conroe. This value was

based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 5.42 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Lake Conroe shifted from a eutrophic classification for the 2000 reporting cycle to a hypereutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Lake Conroe, the chlorophyll *a* criterion is below 30 µg/L but 10% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Lake Conroe, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is not satisfied in the case of Lake Conroe. Reservoir-specific data and information described above indicates a eutrophic classification for Lake Conroe in the 2000 reporting cycle with a shift to a hypereutrophic classification in the 2010 reporting cycle. Reservoir-specific data and information described above indicates a relatively high rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.340 µg/L chlorophyll *a*/year) and an increasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. TCEQ did not identify any CWA §303(d) listings for pH or DO for Lake Conroe. While TCEQ did not identify any nutrient concerns in Lake Conroe, TCEQ did identify nine concerns for chlorophyll *a* in the 2008 through 2010 reporting cycles. 10% of the measurements in the underlying chlorophyll *a* dataset available for Lake Conroe were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is not satisfied in the case of Lake Conroe, EPA not only strongly considered the shift to a hypereutrophic classification in the 2010 reporting cycle, but also strongly considered the fact that 10% of the measurements in the underlying chlorophyll *a* dataset available for Lake Conroe were greater than 30 µg/L. With this being the case, EPA is concerned that the chlorophyll *a* criterion (which is derived and expressed as a long-term central tendency), is not likely to protect designated uses from the effects of high instantaneous chlorophyll *a* concentrations (such as nuisance blooms, toxic cyanobacteria and toxin production, taste and odor compound production, and disinfection byproduct production). Based on the above information, EPA concludes that the chlorophyll *a* criterion of 24.27 µg/L applicable to Lake Conroe is not protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA disapproves this reservoir-specific chlorophyll *a* criterion.

63. <u>Red Bluff Reservoir, Segment 2312, Chlorophyll *a* Criterion 25.14 µg/L (Disapproved)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 37 measurements collected between between October 8, 1990, and August 20, 2008. Of these 37 measurements, 3 were considered to be outliers because they had values greater than 51.5 µg/L. So, the criterion was derived using a final dataset consisting of 34 chlorophyll *a* measurements collected between between October 8, 1990, and August 20, 2008, all of which were equal to or below 47.3 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Red Bluff Reservoir.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Red Bluff Reservoir:

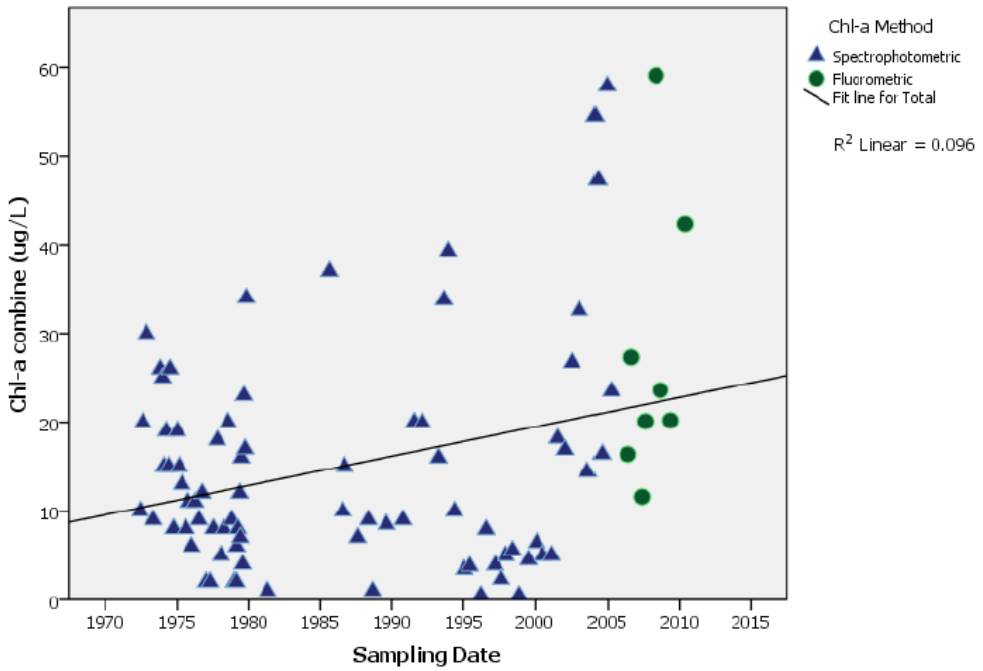
Year	Parameter	Assessment Unit	Assessment Unit Description
2008	Chl-a	2312_01	Texas/New Mexico State Line to Mid-lake
2010	Chl-a	2312_01	From the Red Bluff Dam to mid-lake
2006	HAB/GA	2312_01	Texas/New Mexico State Line to Mid-lake
2008	HAB/GA	2312_01	Texas/New Mexico State Line to Mid-lake
2010	HAB/GA	2312_01	From the Red Bluff Dam to mid-lake
2006	NO3-N	2312_01	Texas/New Mexico State Line to Mid-lake
2008	NO3-N	2312_01	Texas/New Mexico State Line to Mid-lake
2008	Chl-a	2312_02	Mid-lake to dam
2010	Chl-a	2312_02	From mid-lake to the Texas/New Mexico state line
2008	DO	2312_02	Mid-lake to dam
2006	HAB/GA	2312_02	Mid-lake to dam
2008	HAB/GA	2312_02	Mid-lake to dam
2010	HAB/GA	2312_02	From mid-lake to the Texas/New Mexico state line
2006	NH3-N	2312_02	Mid-lake to dam
2008	NH3-N	2312_02	Mid-lake to dam
2006	NO3-N	2312_02	Mid-lake to dam
2010	NO3-N	2312_02	From mid-lake to the Texas/New Mexico state line
2006	OP	2312_02	Mid-lake to dam
2008	OP	2312_02	Mid-lake to dam

Treated Drinking Water Chemical Data: For facilities using source water from Red Bluff Reservoir, TCEQ did not report finding any exceedances of SDWA MCLs for any disinfection byproducts or nitrate in supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Red Bluff Reservoir was not sampled as part of the 2007 NLA.

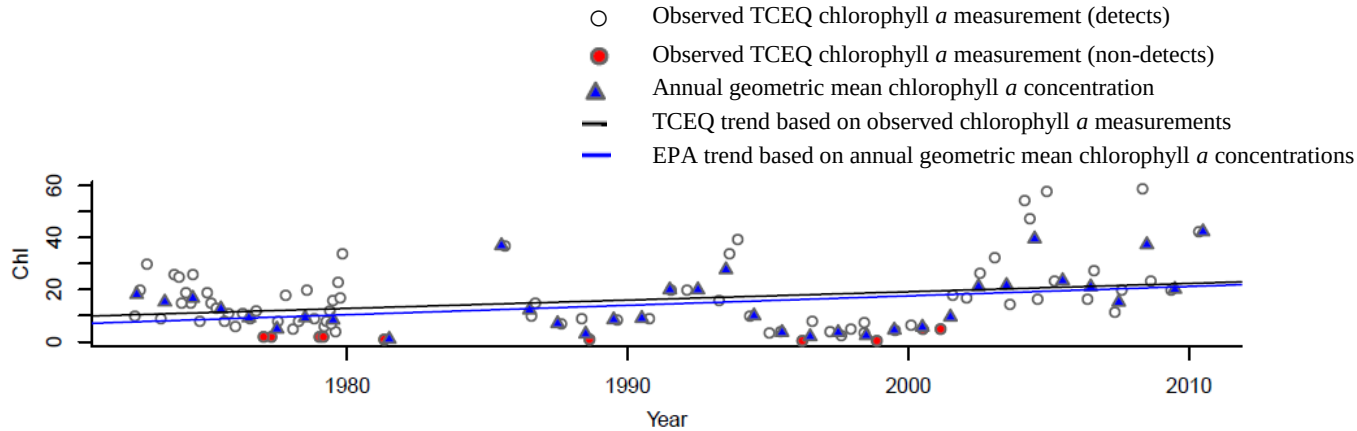
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 85 chlorophyll *a* measurements collected from Red Bluff Reservoir between 1972 and 2010 (see Figure 125). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Red Bluff Reservoir. Based upon the supporting information provided by TCEQ, a shift in methodology does appear to have occurred for this dataset in 2006 (with all data after 2006 being collected using the fluorometric method rather than the spectrophotometric method). Seventy-seven chlorophyll *a* measurements were made using the spectrophotometric method, with 10 of these measurements (~13%) being reported as less than the minimum reporting limits. Eight measurements were made using the fluorometric method, with none of these measurements (0%) being reported as less than the minimum reporting limits. When TCEQ analyzed trends for each of these datasets separately, neither the chlorophyll *a* data collected using the spectrophotometric method nor the chlorophyll *a* data collected using the fluorometric method showed a statistically significant increasing trend.

Figure 125. Chlorophyll *a* Trend for Red Bluff Reservoir Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Red Bluff Reservoir based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 126). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Red Bluff Reservoir, the magnitude of the slope of this increasing trend was relatively high at 0.362 µg/L chlorophyll *a*/year.

Figure 126. Chlorophyll *a* Trends for Red Bluff Reservoir Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Red Bluff Reservoir was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Red Bluff Reservoir between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 61.58 was determined for the 2010 reporting cycle for Red Bluff

Reservoir. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 10.75 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Red Bluff Reservoir shifted from a eutrophic classification for the 2000 reporting cycle to a hypereutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Red Bluff Reservoir, the chlorophyll *a* criterion is below 30 µg/L but 11% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Red Bluff Reservoir, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is not satisfied in the case of Red Bluff Reservoir. Reservoir-specific data and information described above indicates a eutrophic classification for Red Bluff Reservoir in the 2000 reporting cycle with a shift to a hypereutrophic classification in the 2010 reporting cycle. Reservoir-specific data and information described above indicates a relatively high rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.362 µg/L chlorophyll *a*/year) and an increasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. TCEQ did not identify any CWA §303(d) listings for pH or DO for Red Bluff Reservoir. However, TCEQ did identify 11 concerns for chlorophyll *a*, DO, and HAB/GA in Red Bluff Reservoir in the 2006 through 2010 reporting cycles, as well as eight concerns for nutrients (NH3-N, NO3-N, and OP) in the 2006 through 2010 reporting cycles that were repeating. Further, 11% of the measurements in the underlying chlorophyll *a* dataset available for Red Bluff Reservoir were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is not satisfied in the case of Red Bluff Reservoir, EPA not only strongly considered the shift to a hypereutrophic classification in the 2010 reporting cycle, but also strongly considered the relatively high rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.362 µg/L chlorophyll *a*/year) in combination with TCEQ's identification of eight nutrient concerns that were repeating and several HAB/GA concerns. These latter two information sources indicate both the presence of nutrients in concentrations of concern to TCEQ and a biological response in the form of a relatively high chlorophyll *a* accumulation rate and HAB/GA concerns. Additionally, EPA strongly considered the fact that 11% of the measurements in the underlying chlorophyll *a* dataset available for Red Bluff Reservoir were greater than 30 µg/L. With this being the case, EPA is concerned that the chlorophyll *a* criterion (which is derived and expressed as a long-term central tendency), is not likely to protect designated uses from the effects of high instantaneous chlorophyll *a* concentrations (such as nuisance blooms, toxic cyanobacteria and toxin production, taste and odor compound production, and disinfection byproduct production). Based on the above information, EPA concludes that the chlorophyll *a* criterion of 25.14 µg/L applicable to Red Bluff Reservoir is not protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA disapproves this reservoir-specific chlorophyll *a* criterion.

64. <u>Eagle Mountain Reservoir, Segment 0809, Chlorophyll *a* Criterion 25.37 µg/L (Disapproved)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 83 measurements collected between between March 8, 1990, and October 21, 2008. Of these 83 measurements, 1 was considered to be an outlier because it had a value greater than 43.275 µg/L. So, the criterion was derived using a final dataset consisting of 82 chlorophyll *a*

measurements collected between between March 8, 1990, and October 21, 2008, all of which were equal to or below 42.7 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Eagle Mountain Reservoir.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Eagle Mountain Reservoir:

Year	Parameter	Assessment Unit	Assessment Unit Description
2010	Chl-a	0809_01	Lowermost portion of reservoir near east end of dam
2006	DO	0809_01	Lowermost portion of reservoir near east end of dam
2008	DO	0809_01	Lowermost portion of reservoir near east end of dam
2010	DO	0809_01	Lowermost portion of reservoir near east end of dam
2008	NH3-N	0809_03	Ash Creek cove
2010	NH3-N	0809_03	Ash Creek cove
2010	Chl-a	0809_05	Lower portion of reservoir east of Walnut Creek cove
2006	Chl-a	0809_08	Middle portion of reservoir near Cole subdivision
2008	Chl-a	0809_08	Middle portion of reservoir near Cole subdivision
2010	Chl-a	0809_08	Middle portion of reservoir near Cole subdivision
2006	NH3-N	0809_08	Middle portion of reservoir near Cole subdivision
2006	Chl-a	0809_09	Indian Creek cove
2008	Chl-a	0809_09	Indian Creek cove
2010	Chl-a	0809_09	Indian Creek cove
2006	NH3-N	0809_09	Indian Creek cove
2006	Chl-a	0809_10	Upper portion of reservoir near Indian Creek cove
2008	Chl-a	0809_10	Upper portion of reservoir near Indian Creek cove
2010	Chl-a	0809_10	Upper portion of reservoir near Indian Creek cove
2006	Chl-a	0809_12	Upper portion of reservoir near Newark Beach
2008	Chl-a	0809_12	Upper portion of reservoir near Newark Beach
2010	Chl-a	0809_12	Upper portion of reservoir near Newark Beach
2006	Chl-a	0809_14	Mid-Lake, from just above Walnut Cr. Cove to Oakwood Rd. peninsula
2008	Chl-a	0809_14	Mid-Lake, from just above Walnut Cr. Cove to Oakwood Rd. peninsula
2010	Chl-a	0809_14	Mid-Lake, from just above Walnut Cr. Cove to Oakwood Rd. peninsula

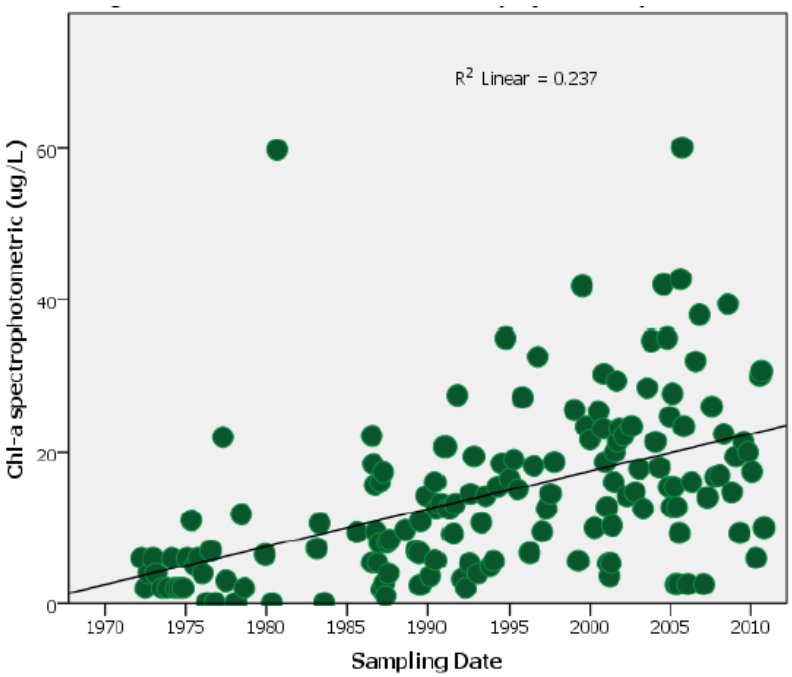
Treated Drinking Water Chemical Data: For facilities using source water from Eagle Mountain Reservoir, TCEQ did not report finding any exceedances of SDWA MCLs for any disinfection byproducts or nitrate in supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Eagle Mountain Reservoir was not sampled as part of the 2007 NLA.

TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 151 chlorophyll *a* measurements collected from Eagle Mountain Reservoir between 1972 and 2010 (see Figure 127). Because TCEQ noted that many of the monitoring entities in the state switched from the

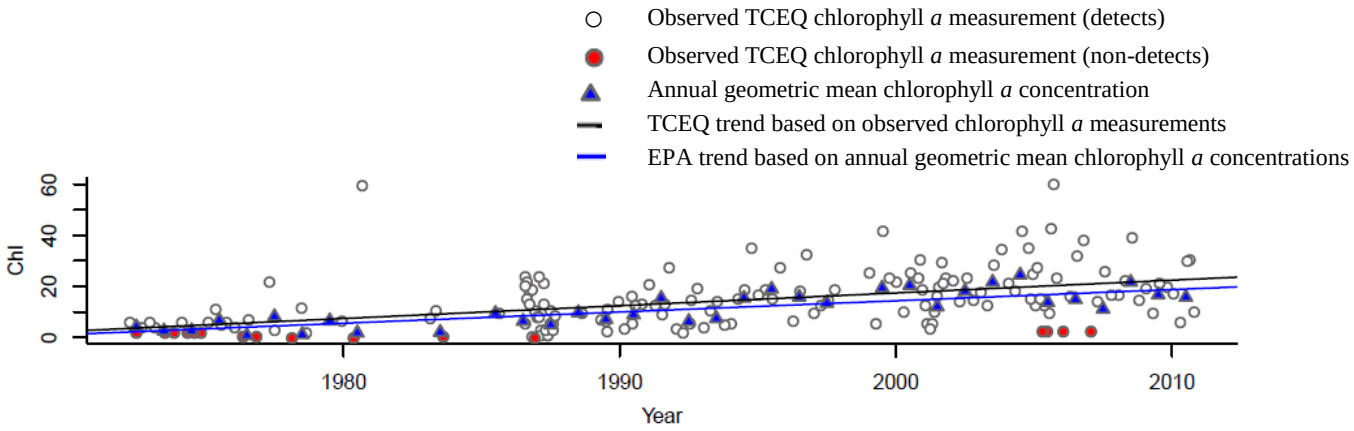
spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Eagle Mountain Reservoir. Based upon the supporting information provided by TCEQ, all of these chlorophyll *a* measurements were determined using the same method (spectrophotometric). Sixteen of these 151 measurements (11%) were reported as being less than the reporting limits. In further analyzing the spectrophotometric method dataset, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) did not affect the statistical significance of this chlorophyll *a* trend to such a degree that the trend became statistically insignificant. Therefore, EPA believes that this increasing trend for Eagle Mountain Reservoir is statistically significant.

Figure 127. Chlorophyll *a* Trend for Eagle Mountain Reservoir Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Eagle Mountain Reservoir based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 128). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Eagle Mountain Reservoir, the magnitude of the slope of this increasing trend was very high, relatively speaking, at 0.440 µg/L chlorophyll *a*/year.

Figure 128. Chlorophyll *a* Trends for Eagle Mountain Reservoir Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Eagle Mountain Reservoir was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Eagle Mountain Reservoir between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 61.96 was determined for the 2010 reporting cycle for Eagle Mountain Reservoir. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 8.4 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Eagle Mountain Reservoir shifted from a eutrophic classification for the 2000 reporting cycle to a hypereutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Eagle Mountain Reservoir, the chlorophyll *a* criterion is below 30 µg/L but 8% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Eagle Mountain Reservoir, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is not satisfied in the case of Eagle Mountain Reservoir. Reservoir-specific data and information described above indicates a eutrophic classification for Eagle Mountain Reservoir in the 2000 reporting cycle with a shift to a hypereutrophic classification in the 2010 reporting cycle. Reservoir-specific data and information described above indicates a very high rate of chlorophyll *a* accumulation, relatively speaking, based on EPA's trend analysis (slope = 0.440 µg/L chlorophyll *a*/year) and a statistically significant increasing trend in chlorophyll *a* concentration based on EPA's review of TCEQ's trend analysis. TCEQ did not identify any CWA §303(d) listings for pH or DO for Eagle Mountain Reservoir. TCEQ identified 20 concerns for DO and chlorophyll *a* in Eagle Mountain Reservoir in the 2006 through 2010 reporting cycles. And, though not considered repeating (as previously defined in Footnote 2), TCEQ identified four nutrient concerns (NH3-N) in the 2006 through 2010 reporting cycles in Eagle Mountain Reservoir. 8% of the measurements in the underlying chlorophyll *a* dataset available for Eagle Mountain Reservoir were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is not satisfied in the case of Eagle Mountain Reservoir, EPA

strongly considered the shift to a hypereutrophic classification in the 2010 reporting cycle, along with the very high rate of chlorophyll *a* accumulation, relatively speaking, based on EPA's trend analysis (slope = 0.440 µg/L chlorophyll *a*/year). Based on the above information, EPA concludes that the chlorophyll *a* criterion of 25.37 µg/L applicable to Eagle Mountain Reservoir is not protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA disapproves this reservoir-specific chlorophyll *a* criterion.

65. Benbrook Lake, Segment 0830, Chlorophyll *a* Criterion 27.15 µg/L (Disapproved)

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 88 measurements collected between between January 4, 1990, and September 9, 2008. Of these 88 measurements, 2 were considered to be outliers because they had values greater than 50.9625 µg/L. So, the criterion was derived using a final dataset consisting of 86 chlorophyll *a* measurements collected between between January 4, 1990, and September 9, 2008, all of which were equal to or below 50.7 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Benbrook Lake.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Benbrook Lake:

Year	Parameter	Assessment Unit	Assessment Unit Description
2008	Chl-a	0830_01	Lower portion of reservoir
2010	Chl-a	0830_01	Lower portion of reservoir
2008	NH3-N	0830_01	Lower portion of reservoir
2008	Chl-a	0830_02	Middle portion of reservoir
2010	Chl-a	0830_02	Middle portion of reservoir
2006	NH3-N	0830_02	Middle portion of reservoir
2008	NH3-N	0830_02	Middle portion of reservoir
2006	Chl-a	0830_03	Upper portion of reservoir
2008	Chl-a	0830_03	Upper portion of reservoir
2010	Chl-a	0830_03	Upper portion of reservoir
2010	Chl-a	0830_05	Rock/Mustang Creek arm of Benbrook Lake

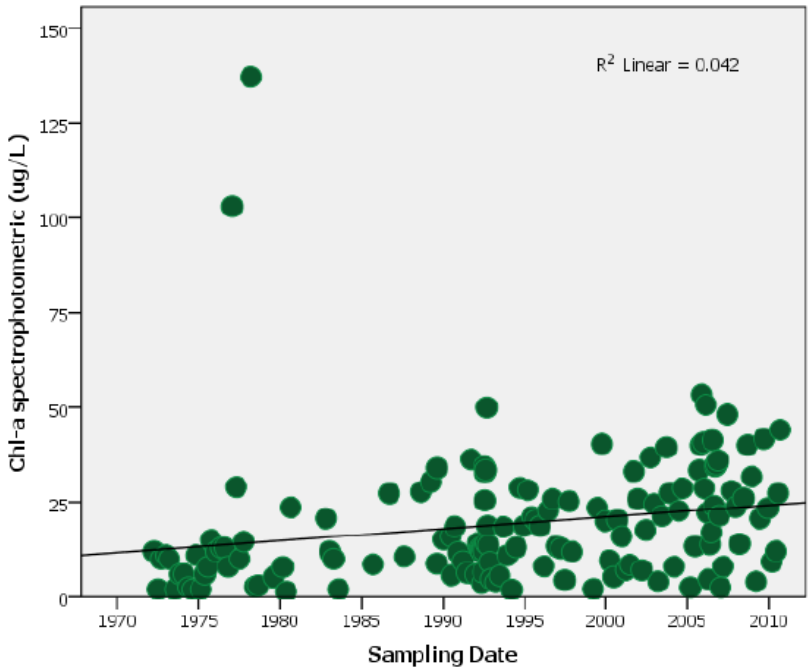
Treated Drinking Water Chemical Data: For facilities using source water from Benbrook Lake, TCEQ did not report finding any exceedances of SDWA MCLs for any disinfection byproducts or nitrate in supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Benbrook Lake was not sampled as part of the 2007 NLA.

TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 146 chlorophyll *a* measurements collected from Benbrook Lake between 1972 and 2010 (see Figure 129). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Benbrook Lake. Based upon the supporting information

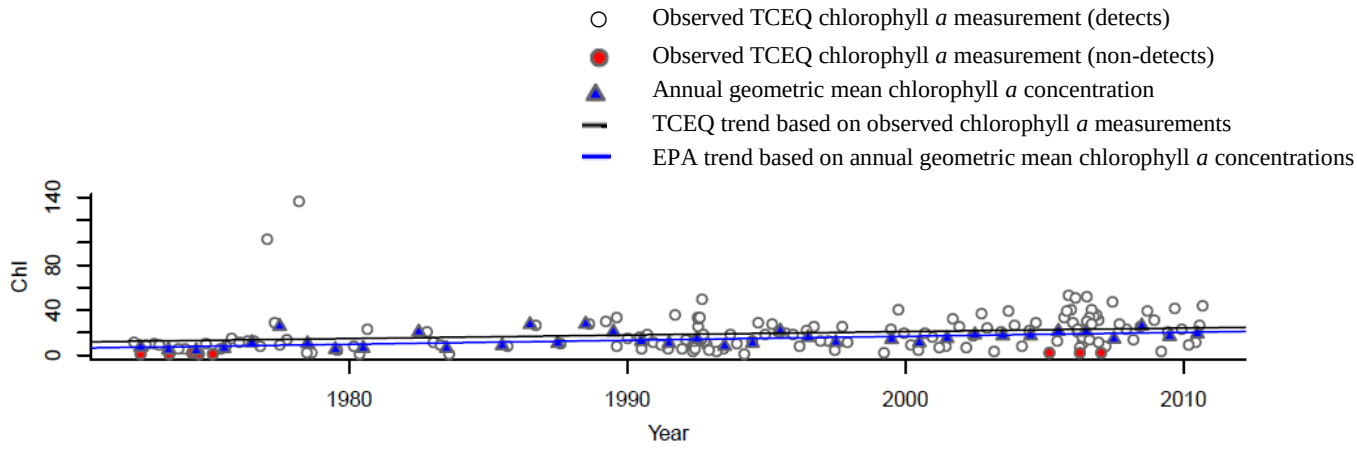
provided by TCEQ, all of these chlorophyll *a* measurements were determined using the same method (spectrophotometric). Eight of these 146 measurements (5%) were reported as being less than the reporting limits. In further analyzing the spectrophotometric method dataset, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) did not affect the statistical significance of this chlorophyll *a* trend to such a degree that the trend became statistically insignificant. Therefore, EPA believes that this increasing trend for Benbrook Lake is statistically significant.

Figure 129. Chlorophyll *a* Trend for Benbrook Lake Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Benbrook Lake based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 130). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Benbrook Lake, the magnitude of the slope of this increasing trend was relatively high at 0.351 µg/L chlorophyll *a*/year.

Figure 130. Chlorophyll *a* Trends for Benbrook Lake Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Benbrook Lake was not included in TCEQ's report titled *Trophic Classification of Texas Reservoirs*.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Benbrook Lake, the chlorophyll *a* criterion is below 30 µg/L but 18% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Benbrook Lake, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is not satisfied in the case of Benbrook Lake. Trophic state classification information was not available for Benbrook Lake. Reservoir-specific data and information described above indicates a relatively high rate of chlorophyll *a* accumulation based on EPA's trend analysis (slope = 0.351 µg/L chlorophyll *a*/year) and a statistically significant increasing trend in chlorophyll *a* concentration based on EPA's review of TCEQ's trend analysis. TCEQ did not identify any CWA §303(d) listings for pH or DO for Benbrook Lake. TCEQ identified eight concerns for chlorophyll *a* in Benbrook Lake in the 2006 through 2010 reporting cycles. And, though not considered repeating (as previously defined in Footnote 2), TCEQ identified three nutrient concerns (NH3-N) in the 2006 through 2008 reporting cycles in Benbrook Lake. Further, 18% of the measurements in the underlying chlorophyll *a* dataset available for Benbrook Lake were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is not satisfied in the case of Benbrook Lake, EPA strongly considered this last information source. With 18% of the measurements in the underlying chlorophyll *a* dataset available for Benbrook Lake being greater than 30 µg/L, EPA is concerned that the chlorophyll *a* criterion (which is derived and expressed as a long-term central tendency), is not likely to protect designated uses from the effects of high instantaneous chlorophyll *a* concentrations (such as nuisance blooms, toxic cyanobacteria and toxin production, taste and odor compound production, and disinfection byproduct production). Based on the above information, EPA concludes that the chlorophyll *a* criterion of 27.15 µg/L applicable to Benbrook Lake is not protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA disapproves this reservoir-specific chlorophyll *a* criterion.

66. Lake Palestine, Segment 0605, Chlorophyll *a* Criterion 27.34 µg/L (Disapproved)

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 39 measurements collected between between November 11, 1998, and November 3, 2008. Of these 39 measurements, 1 was considered to be an outlier because it had a value greater than 42.7475 µg/L. So, the criterion was derived using a final dataset consisting of 38 chlorophyll *a* measurements collected between between November 11, 1998, and November 3, 2008, all of which were equal to or below 42.2 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for pH and DO listings in the 2000 through 2010 reporting cycles, the following 303(d) listings were identified for Lake Palestine:

Year	Parameter	Assessment Unit	Assessment Unit Description
2006	pH	0605_03	Mid-lake near Tyler PWS intake
2008	pH	0605_03	Mid-lake near Tyler PWS intake
2010	pH	0605_03	Upper mid-lake including Tyler Public Water Supply
2008	pH	0605_09	Flat Creek Arm
2010	pH	0605_09	Flat Creek Arm
2008	pH	0605_10	Upper Lake
2010	pH	0605_10	Upper Lake

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Lake Palestine:

Year	Parameter	Assessment Unit	Assessment Unit Description
2010	Chl-a	0605_01	Lower portion of reservoir near dam to first bend in reservoir
2006	DO	0605_01	Lower portion of reservoir near dam
2008	DO	0605_01	Lower portion of reservoir near dam
2010	DO	0605_01	Lower portion of reservoir near dam to first bend in reservoir
2008	Chl-a	0605_03	Mid-lake near Tyler PWS intake
2010	Chl-a	0605_03	Upper mid-lake including Tyler Public Water Supply intake
2008	DO	0605_04	Upper lake (Neches arm)
2008	NH3-N	0605_04	Upper lake (Neches arm)
2008	NO3-N	0605_04	Upper lake (Neches arm)
2008	OP	0605_04	Upper lake (Neches arm)
2006	pH	0605_04	Upper lake (Neches arm)
2008	TP	0605_04	Upper lake (Neches arm)
2006	NH3-N	0605_05	Indian Creek Cove
2006	NO3-N	0605_05	Indian Creek Cove
2006	OP	0605_05	Indian Creek Cove
2006	TP	0605_05	Indian Creek Cove
2006	NH3-N	0605_06	Headwaters (Neches River)
2006	NO3-N	0605_06	Headwaters (Neches River)
2006	OP	0605_06	Headwaters (Neches River)
2006	TP	0605_06	Headwaters (Neches River)
2008	Chl-a	0605_07	Headwaters (Kickapoo Creek arm)
2008	DO	0605_07	Headwaters (Kickapoo Creek arm)
2006	NH3-N	0605_07	Headwaters (Kickapoo Creek arm)
2008	NH3-N	0605_07	Headwaters (Kickapoo Creek arm)

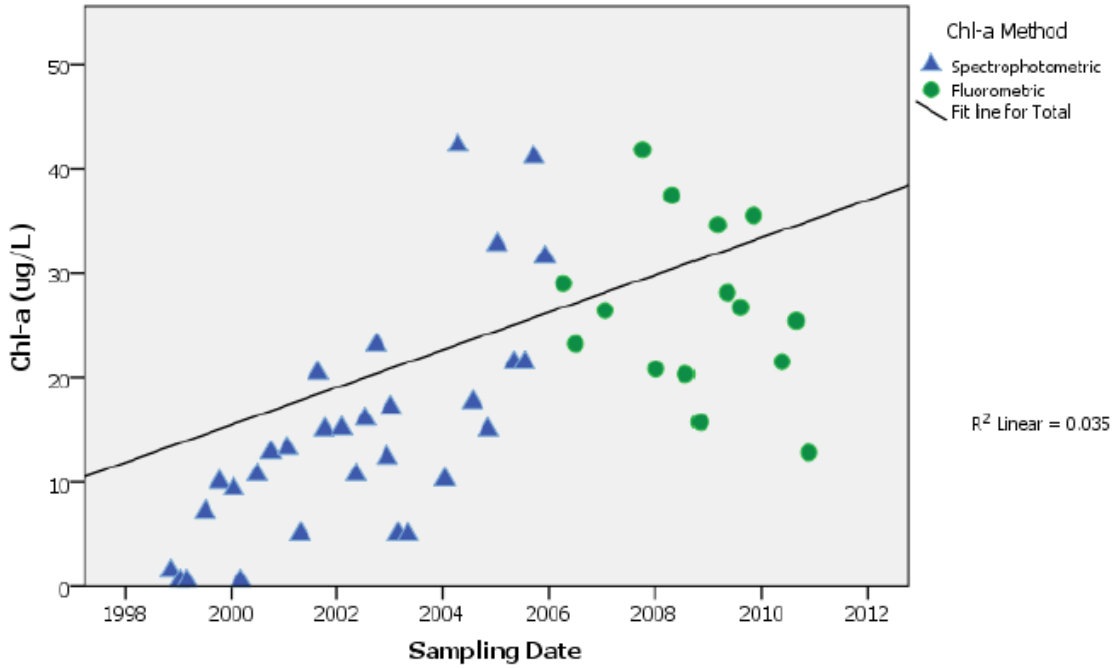
Year	Parameter	Assessment Unit	Assessment Unit Description
2006	NO3-N	0605_07	Headwaters (Kickapoo Creek arm)
2008	NO3-N	0605_07	Headwaters (Kickapoo Creek arm)
2006	OP	0605_07	Headwaters (Kickapoo Creek arm)
2008	OP	0605_07	Headwaters (Kickapoo Creek arm)
2006	DO	0605_08	Flat Creek Headwaters
2008	DO	0605_08	Flat Creek Headwaters
2006	NH3-N	0605_08	Flat Creek Headwaters
2008	NH3-N	0605_08	Flat Creek Headwaters
2006	NO3-N	0605_08	Flat Creek Headwaters
2008	NO3-N	0605_08	Flat Creek Headwaters
2006	OP	0605_08	Flat Creek Headwaters
2008	OP	0605_08	Flat Creek Headwaters
2008	Chl-a	0605_09	Flat Creek arm
2010	Chl-a	0605_09	Flat Creek arm
2008	Chl-a	0605_10	Upper Lake
2010	Chl-a	0605_10	Upper Lake
2010	Chl-a	0605_11	From the SH 155 Bridge crossing to the Flat Creek Arm and across the main portion of the lake at the Flat Creek Arm

Treated Drinking Water Chemical Data: For facilities using source water from Lake Palestine, TCEQ did not report finding any exceedances of SDWA MCLs for any disinfection byproducts or nitrate in supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Lake Palestine was sampled two times as part of the 2007 NLA. During the first sampling event, the chlorophyll *a* concentration measured was 44.15 µg/L, indicating a moderate risk of exposure based on the chlorophyll *a* thresholds used in the NLA study. During the first sampling event, microcystin was detected above the reporting limit of 0.1 ug/L at a concentration of 0.26 ug/L, indicating a low risk of exposure based on the microcystin thresholds used in the NLA study. The cyanobacteria cell count during the first sampling event was less than 20,000 cells per milliliter, indicating a low risk of exposure based on the cyanobacteria thresholds used in the NLA study. During the second sampling event, the chlorophyll *a* concentration measured was 25.4 µg/L, indicating a moderate risk of exposure based on the chlorophyll *a* thresholds used in the NLA study. During the second sampling event, microcystin was detected above the reporting limit of 0.1 ug/L at a concentration of 0.2 ug/L, indicating a low risk of exposure based on the microcystin thresholds used in the NLA study. The cyanobacteria cell count during the second sampling event was between 20,000 and 100,000 cells per milliliter, indicating a moderate risk of exposure based on the cyanobacteria thresholds used in the NLA study.

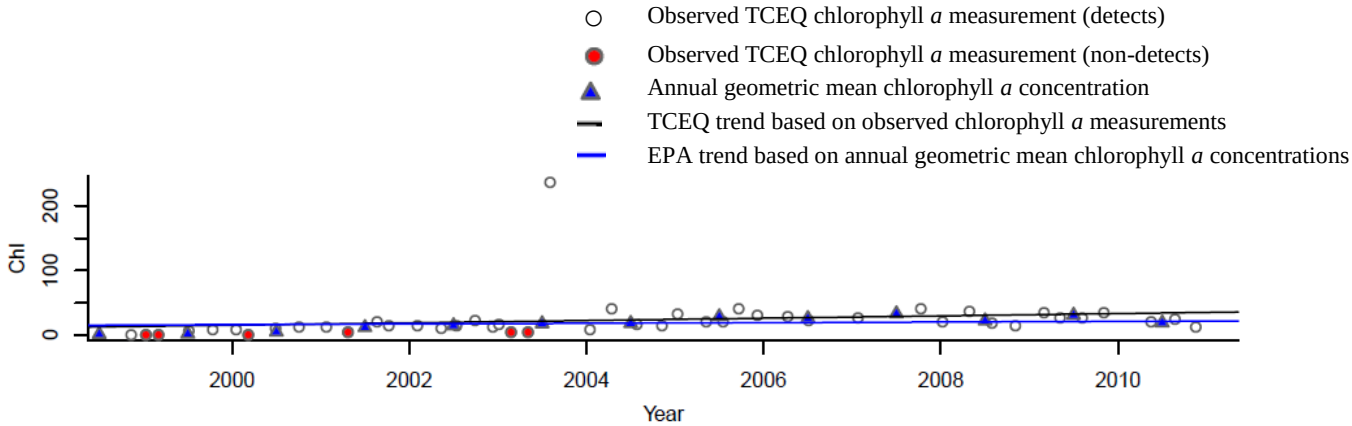
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ did not identify any statistically significant increasing trends in chlorophyll *a* concentrations for Lake Palestine (see Figure 131).

Figure 131. Chlorophyll *a* Trend for Lake Palestine Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Lake Palestine based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 132). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Lake Palestine, the magnitude of the slope of this increasing trend was very high, relatively speaking, at 0.498 µg/L chlorophyll *a*/year.

Figure 132. Chlorophyll *a* Trends for Lake Palestine Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Lake Palestine was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Lake Palestine between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 61.46 was determined for the 2010 reporting cycle for Lake Palestine. This value

was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 10.45 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Lake Palestine shifted from a eutrophic classification for the 2000 reporting cycle to a hypereutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Lake Palestine, the chlorophyll *a* criterion is below 30 µg/L but 18% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Lake Palestine, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is not satisfied in the case of Lake Palestine. Reservoir-specific data and information described above indicates a eutrophic classification for Lake Palestine in the 2000 reporting cycle with a shift to a hypereutrophic classification in the 2010 reporting cycle. Reservoir-specific data and information described above indicates a very high rate of chlorophyll *a* accumulation, relatively speaking, based on EPA's trend analysis (slope = 0.498 µg/L chlorophyll *a*/year) and an increasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. TCEQ identified seven CWA §303(d) listings for pH in Lake Palestine in the 2006 through 2010 reporting cycles. Additionally, TCEQ identified 17 concerns for chlorophyll *a*, DO, and pH in Lake Palestine in the 2006 through 2010 reporting cycles, as well as 24 concerns for nutrients (NH3-N, NO3-N, OP and TP) in the 2006 through 2008 reporting cycles that were repeating. Data from the first sampling event as part of the 2007 NLA indicated a moderate risk of exposure based on chlorophyll *a* thresholds and a low risk of exposure based on microcystin and cyanobacteria thresholds. Data from the second sampling event as part of the 2007 NLA indicated a moderate risk of exposure based on chlorophyll *a* and cyanobacteria thresholds and a low risk of exposure based on microcystin thresholds. Further, 18% of the measurements in the underlying chlorophyll *a* dataset available for Lake Palestine were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is not satisfied in the case of Lake Palestine, EPA not only strongly considered the shift to a hypereutrophic classification in the 2010 reporting cycle, but also strongly considered the very high rate of chlorophyll *a* accumulation, relatively speaking, based on EPA's trend analysis (slope = 0.498 µg/L chlorophyll *a*/year) in combination with TCEQ's identification of 24 nutrient concerns that were repeating. These latter two information sources indicate both the presence of nutrients in concentrations of concern to TCEQ and a biological response in the form of a very high chlorophyll *a* accumulation rate. Additionally, EPA strongly considered the fact that 18% of the measurements in the underlying chlorophyll *a* dataset available for Lake Palestine were greater than 30 µg/L. With this being the case, EPA is concerned that the chlorophyll *a* criterion (which is derived and expressed as a long-term central tendency), is not likely to protect designated uses from the effects of high instantaneous chlorophyll *a* concentrations (such as nuisance blooms, toxic cyanobacteria and toxin production, taste and odor compound production, and disinfection byproduct production). Based on the above information, EPA concludes that the chlorophyll *a* criterion of 27.34 µg/L applicable to Lake Palestine is not protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA disapproves this reservoir-specific chlorophyll *a* criterion.

67. Proctor Lake, Segment 1222, Chlorophyll *a* Criterion 28.15 µg/L (Disapproved)

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 56 measurements collected between between February 27, 1990, and June 17, 2008. Of these 56 measurements, 4 were considered to be outliers because they had values greater than 58.6625 µg/L. So, the criterion was derived using a final dataset consisting of 52 chlorophyll *a* measurements collected between between February 27, 1990, and June 17, 2008, all of which were equal to or below 53.6 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for pH and DO listings in the 2000 through 2010 reporting cycles, the following 303(d) listings were identified for Proctor Lake:

Year	Parameter	Assessment Unit	Assessment Unit Description
2000	DO	n/a	Entire reservoir
2002	DO	n/a	Rush-Copperas Creek arm of lake
2004	DO	n/a	Rush-Copperas Creek arm of lake
2002	DO	n/a	Sabana River arm of lake
2004	DO	n/a	Sabana River arm of lake

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Proctor Lake:

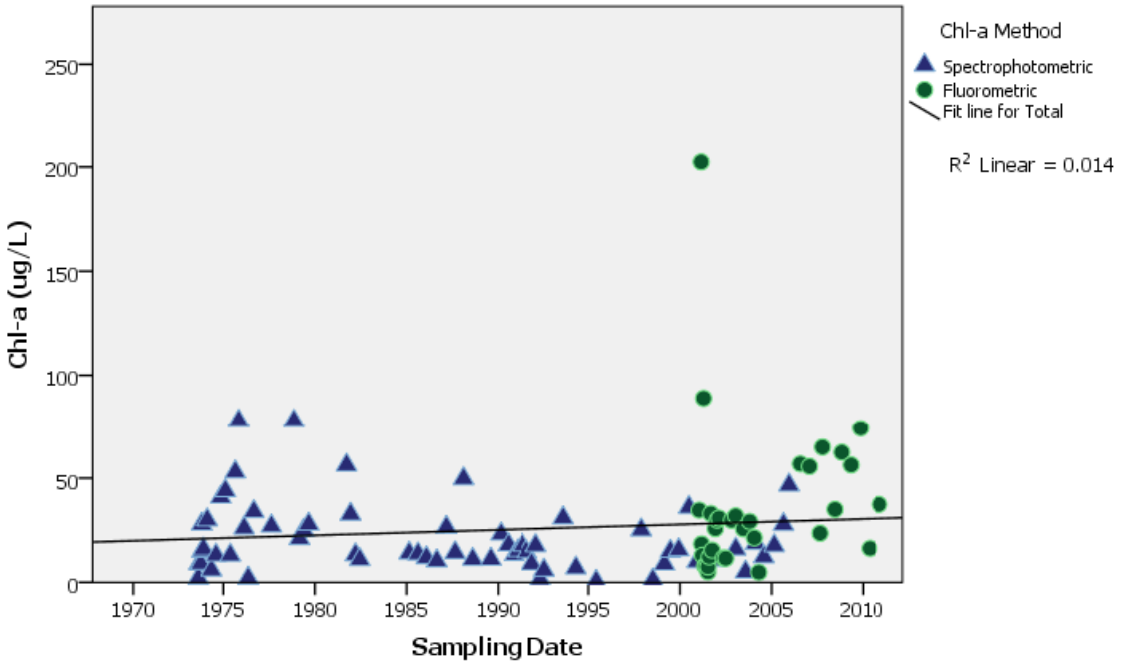
Year	Parameter	Assessment Unit	Assessment Unit Description
2008	Chl-a	1222_01	Sabana River arm of lake
2010	Chl-a	1222_01	Sabana River arm of lake
2008	TP	1222_01	Sabana River arm of lake
2010	TP	1222_01	Sabana River arm of lake
2006	Chl-a	1222_02	Copperas / Duncan Creeks arm of lake
2008	Chl-a	1222_02	Copperas / Duncan Creeks arm of lake
2010	Chl-a	1222_02	Copperas / Duncan Creeks arm of lake
2006	Chl-a	1222_03	Portion of water body near dam
2008	Chl-a	1222_03	Portion of water body near dam
2010	Chl-a	1222_03	Portion of water body near dam

Treated Drinking Water Chemical Data: For facilities using source water from Proctor Lake, TCEQ did not report finding any exceedances of SDWA MCLs for any disinfection byproducts or nitrate in supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Proctor Lake was not sampled as part of the 2007 NLA.

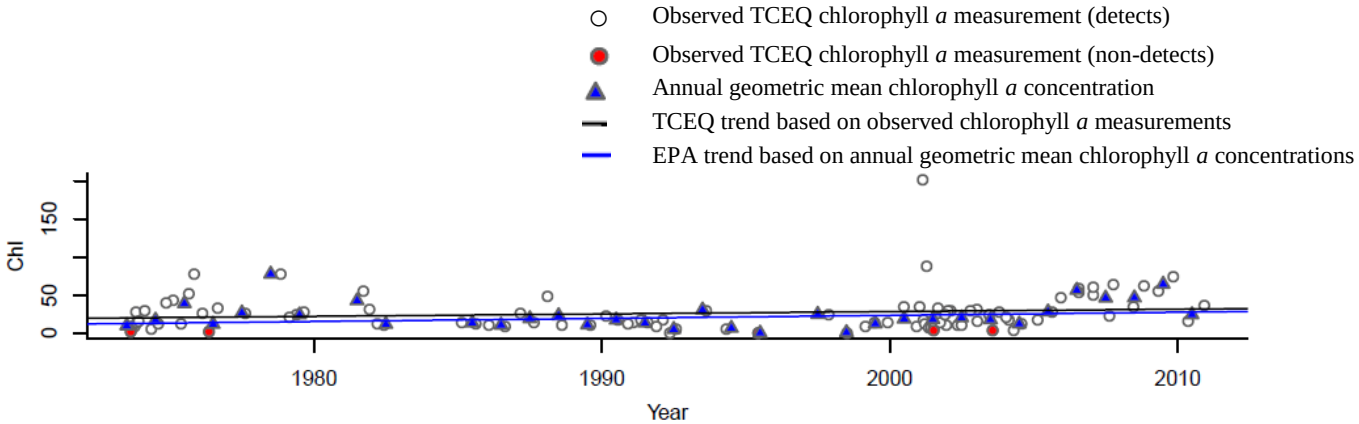
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ did not identify any statistically significant increasing trends in chlorophyll *a* concentrations for Proctor Lake (see Figure 133).

Figure 133. Chlorophyll *a* Trend for Proctor Lake Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Proctor Lake based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 134). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Proctor Lake, the magnitude of the slope of this increasing trend was very high, relatively speaking, at 0.405 µg/L chlorophyll *a*/year.

Figure 134. Chlorophyll *a* Trends for Proctor Lake Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Proctor Lake was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Proctor Lake between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 58.68 was determined for the 2010 reporting cycle for Proctor Lake. This value

was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 6.45 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Proctor Lake shifted from a eutrophic classification for the 2000 reporting cycle to a hypereutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Proctor Lake, the chlorophyll *a* criterion is below 30 µg/L but 25% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Proctor Lake, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is not satisfied in the case of Proctor Lake. Reservoir-specific data and information described above indicates a eutrophic classification for Proctor Lake in the 2000 reporting cycle with a shift to a hypereutrophic classification in the 2010 reporting cycle. Reservoir-specific data and information described above indicates a very high rate of chlorophyll *a* accumulation, relatively speaking, based on EPA's trend analysis (slope = 0.405 µg/L chlorophyll *a*/year) and an increasing trend in chlorophyll *a* concentration that was not statistically significant based on EPA's review of TCEQ's trend analysis. TCEQ identified five CWA §303(d) listings for DO in Proctor Lake in the 2000 through 2004 reporting cycles. TCEQ identified eight concerns for chlorophyll *a* in Proctor Lake in the 2006 through 2010 reporting cycles. And, though not considered repeating (as previously defined in Footnote 2), TCEQ identified two nutrient concerns (TP) in the 2008 through 2010 reporting cycles in Proctor Lake. 25% of the measurements in the underlying chlorophyll *a* dataset available for Proctor Lake were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is not satisfied in the case of Proctor Lake, EPA not only strongly considered the shift to a hypereutrophic classification in the 2010 reporting cycle, but also strongly considered the fact that 25% of the measurements in the underlying chlorophyll *a* dataset available for Proctor Lake were greater than 30 µg/L. With this being the case, EPA is concerned that the chlorophyll *a* criterion (which is derived and expressed as a long-term central tendency), is not likely to protect designated uses from the effects of high instantaneous chlorophyll *a* concentrations (such as nuisance blooms, toxic cyanobacteria and toxin production, taste and odor compound production, and disinfection byproduct production). Based on the above information, EPA concludes that the chlorophyll *a* criterion of 28.15 µg/L applicable to Proctor Lake is not protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA disapproves this reservoir-specific chlorophyll *a* criterion.

68. <u>Cedar Creek Reservoir, Segment 0818, Chlorophyll *a* Criterion 30.40 µg/L (Disapproved)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 51 measurements collected between between June 9, 1990, and October 1, 2008. Of these 51 measurements, 3 were considered to be outliers because they had values greater than 49.125 µg/L. So, the criterion was derived using a final dataset consisting of 48 chlorophyll *a* measurements collected between between June 9, 1990, and October 1, 2008, all of which were equal to or below 47.2 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for pH and DO listings in the 2000 through 2010 reporting cycles, the following 303(d) listings were identified for Cedar Creek Reservoir:

Year	Parameter	Assessment Unit	Assessment Unit Description
2002	high pH	n/a	Lowermost portion of reservoir, adjacent to dam
2004	high pH	n/a	Lowermost portion of reservoir, adjacent to dam
2006	pH	0818_01	Lowermost portion of reservoir, adjacent to dam
2008	pH	0818_01	1674
2010	pH	0818_01	Lowermost portion of reservoir, adjacent to dam
2002	high pH	n/a	Caney Creek cove
2004	high pH	n/a	Caney Creek cove
2006	pH	0818_02	Caney Creek cove
2008	pH	0818_02	Caney Creek cove
2010	pH	0818_02	Caney Creek cove
2002	high pH	n/a	Clear Creek cove
2004	high pH	n/a	Clear Creek cove
2006	pH	0818_03	Clear Creek cove
2008	pH	0818_03	Clear Creek cove
2010	pH	0818_03	Clear Creek cove
2002	high pH	n/a	Lower portion of reservoir east of Key Ranch Estates
2004	high pH	n/a	Lower portion of reservoir east of Key Ranch Estates
2006	pH	0818_04	Lower portion of reservoir east of Key Ranch Estates
2008	pH	0818_04	Lower portion of reservoir east of Key Ranch Estates
2002	high pH	n/a	Cove off lower portion of reservoir adjacent to Clearview Estates
2004	high pH	n/a	Cove off lower portion of reservoir adjacent to Clearview Estates
2006	pH	0818_05	Cove off lower portion of reservoir adjacent to Clearview Estates
2008	pH	0818_05	Cove off lower portion of reservoir adjacent to Clearview Estates
2010	pH	0818_05	Cove off lower portion of reservoir adjacent to Clearview Estates
2002	high pH	n/a	Middle portion of reservoir downstream of Twin Creeks cove
2004	high pH	n/a	Middle portion of reservoir downstream of Twin Creeks cove
2006	pH	0818_06	Middle portion of reservoir downstream of Twin Creeks cove
2008	pH	0818_06	Middle portion of reservoir downstream of Twin Creeks cove
2010	pH	0818_06	Middle portion of reservoir downstream of Twin Creeks cove
2002	high pH	n/a	Twin Creeks cove
2004	high pH	n/a	Twin Creeks cove
2006	pH	0818_07	Twin Creeks cove
2008	pH	0818_07	Twin Creeks cove
2010	pH	0818_07	Twin Creeks cove
2006	pH	0818_08	Prairie Creek cove
2008	pH	0818_08	Prairie Creek cove
2010	pH	0818_08	Prairie Creek cove
2002	high pH	n/a	Upper portion of reservoir adjacent to Lacy Fork cove
2004	high pH	n/a	Upper portion of reservoir adjacent to Lacy Fork cove
2006	pH	0818_09	Upper portion of reservoir adjacent to Lacy Fork cove
2008	pH	0818_09	Upper portion of reservoir adjacent to Lacy Fork cove
2010	pH	0818_09	Upper portion of reservoir adjacent to Lacy Fork cove
2002	high pH	n/a	Upper portion of reservoir east of Tolosa
2004	high pH	n/a	Upper portion of reservoir east of Tolosa
2006	pH	0818_11	Upper portion of reservoir east of Tolosa
2008	pH	0818_11	Upper portion of reservoir east of Tolosa
2010	pH	0818_11	Upper portion of reservoir east of Tolosa
2002	high pH	n/a	Uppermost portion of reservoir downstream of Kings Creek

Year	Parameter	Assessment Unit	Assessment Unit Description
2004	high pH	n/a	Uppermost portion of reservoir downstream of Kings Creek
2006	pH	0818_12	Uppermost portion of reservoir downstream of Kings Creek
2008	pH	0818_12	Uppermost portion of reservoir downstream of Kings Creek
2010	pH	0818_12	Uppermost portion of reservoir downstream of Kings Creek

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Cedar Creek Reservoir:

Year	Parameter	Assessment Unit	Assessment Unit Description
2006	Chl-a	0818_01	Lowermost portion of the reservoir, adjacent to the dam.
2008	Chl-a	0818_01	1674
2010	Chl-a	0818_01	Lowermost portion of the reservoir, adjacent to the dam.
2008	NH3-N	0818_02	Caney Creek cove
2010	NH3-N	0818_02	Caney Creek cove
2006	Chl-a	0818_04	Lower portion of reservoir east of Key Ranch Estates
2008	Chl-a	0818_04	Lower portion of reservoir east of Key Ranch Estates
2010	Chl-a	0818_04	Lower portion of reservoir east of Key Ranch Estates
2006	NH3-N	0818_05	Cove off lower portion of reservoir adjacent to Clearview Estates
2008	NH3-N	0818_05	Cove off lower portion of reservoir adjacent to Clearview Estates
2010	NH3-N	0818_05	Cove off lower portion of reservoir adjacent to Clearview Estates
2006	Chl-a	0818_06	Middle portion of reservoir downstream of Twin Creeks cove
2008	Chl-a	0818_06	Middle portion of reservoir downstream of Twin Creeks cove
2010	Chl-a	0818_06	Middle portion of reservoir downstream of Twin Creeks cove
2006	Chl-a	0818_08	Prairie Creek cove
2008	Chl-a	0818_08	Prairie Creek cove
2010	Chl-a	0818_08	Prairie Creek cove
2006	NH3-N	0818_08	Prairie Creek cove
2008	NH3-N	0818_08	Prairie Creek cove
2010	NH3-N	0818_08	Prairie Creek cove
2008	Chl-a	0818_09	Upper portion of reservoir adjacent to Lacy Fork cove
2010	Chl-a	0818_09	Upper portion of reservoir adjacent to Lacy Fork cove
2006	Chl-a	0818_10	Lacy Fork cove
2008	Chl-a	0818_10	Lacy Fork cove
2010	Chl-a	0818_10	Lacy Fork cove
2006	NH3-N	0818_10	Lacy Fork cove
2006	TP	0818_10	Lacy Fork cove
2006	Chl-a	0818_11	Upper portion of reservoir east of Tolosa
2008	Chl-a	0818_11	Upper portion of reservoir east of Tolosa
2010	Chl-a	0818_11	Upper portion of reservoir east of Tolosa
2006	Chl-a	0818_12	Uppermost portion of reservoir downstream of Kings Creek
2006	NO3-N	0818_12	Uppermost portion of reservoir downstream of Kings Creek
2006	OP	0818_12	Uppermost portion of reservoir downstream of Kings Creek
2006	TP	0818_12	Uppermost portion of reservoir downstream of Kings Creek
2008	Chl-a	0818_13	Cedar Creek cove
2010	Chl-a	0818_13	Cedar Creek cove
2008	DO	0818_13	Cedar Creek cove
2010	DO	0818_13	Cedar Creek cove
2006	NH3-N	0818_13	Cedar Creek cove
2008	NH3-N	0818_13	Cedar Creek cove
2010	NH3-N	0818_13	Cedar Creek cove

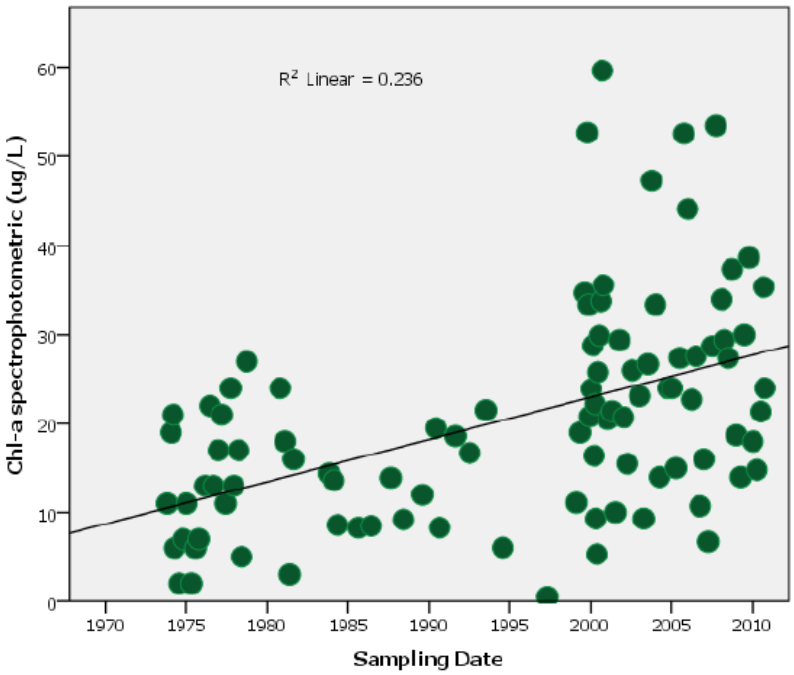
Year	Parameter	Assessment Unit	Assessment Unit Description
2008	OP	0818_13	Cedar Creek cove
2010	OP	0818_13	Cedar Creek cove
2008	TP	0818_13	Cedar Creek cove
2010	TP	0818_13	Cedar Creek cove

Treated Drinking Water Chemical Data: In supporting documentation provided to EPA on February 24, 2012, TCEQ identified one facility using source water from Cedar Creek Reservoir which reported periodic occurrences of haloacetic acids above the SDWA MCL.

2007 National Lakes Assessment Data: Cedar Creek Reservoir was not sampled as part of the 2007 NLA.

TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 96 chlorophyll *a* measurements collected from Cedar Creek Reservoir between 1973 and 2010 (see Figure 135). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Cedar Creek Reservoir. Based upon the supporting information provided by TCEQ, all of these chlorophyll *a* measurements were determined using the same method (spectrophotometric). Three of these 96 measurements (~3%) were reported as being less than the reporting limits. In further analyzing the spectrophotometric method dataset, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) did not affect the statistical significance of this chlorophyll *a* trend to such a degree that the trend became statistically insignificant. Therefore, EPA believes that this increasing trend for Cedar Creek Reservoir is statistically significant.

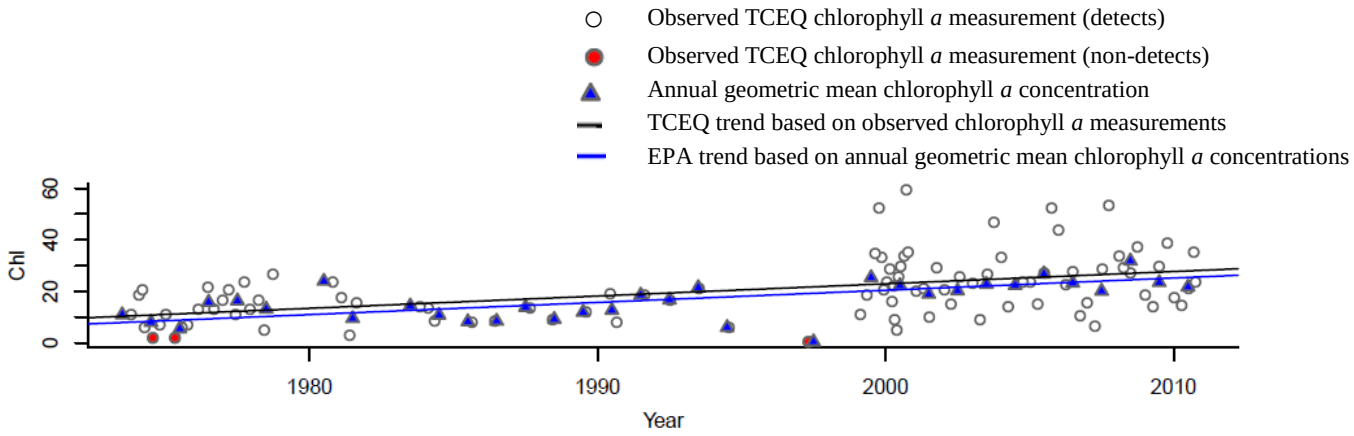
Figure 135. Chlorophyll *a* Trend for Cedar Creek Reservoir Resulting from TCEQ Trend Analysis.



Additionally, the June 2008 Cedar Creek Watershed Protection Plan[7] developed by the Cedar Creek Watershed Partnership with support from multiple federal, state, and local entities under the coordination of the North Central Texas Water Quality Project references an increasing chlorophyll *a* trend in the reservoir based on water quality monitoring data collected by Tarrant Regional Water District since 1989. Watershed planning documents note that this trend is the result of elevated nutrient levels, particularly phosphorus, and cite urban influences as well as the historical farming practices in the watershed combined with highly erodible clay soils as representing the primary causes of nutrient pollution in the reservoir.

EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Cedar Creek Reservoir based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 136). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Cedar Creek Reservoir, the magnitude of the slope of this increasing trend was very high, relatively speaking, at 0.473 µg/L chlorophyll *a*/year.

Figure 136. Chlorophyll *a* Trends for Cedar Creek Reservoir Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Cedar Creek Reservoir was not included in TCEQ's report titled *Trophic Classification of Texas Reservoirs*.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Cedar Creek Reservoir, the chlorophyll *a* criterion is above 30 µg/L and 15% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Cedar Creek Reservoir, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is not satisfied in the case of Cedar Creek Reservoir. Trophic state classification information was not available for Cedar Creek Reservoir. Reservoir-specific data and information described above indicates a very high rate of chlorophyll *a* accumulation, relatively speaking, based on EPA's trend analysis (slope = 0.473 µg/L chlorophyll *a*/year) and a statistically significant

[7] Cedar Creek Watershed Protection Plan available at http://nctx-water.tamu.edu/media/1465/cedarcreekwpp.pdf

increasing trend in chlorophyll *a* concentration based on EPA's review of TCEQ's trend analysis. TCEQ identified 52 CWA §303(d) listings for pH for Cedar Creek Reservoir in the 2002 through 2010 reporting cycles. TCEQ also identified 25 concerns for chlorophyll *a* and DO in Cedar Creek Reservoir in the 2006 through 2010 reporting cycles. Additionally, TCEQ identified 20 concerns for nutrients (NH3-N, NO3-N, OP, and TP) in Cedar Creek Reservoir that were repeating. TCEQ identified one facility using source water from Cedar Creek Reservoir which reported periodic occurrences of haloacetic acids above the SDWA MCL. Further, the chlorophyll *a* criterion for Cedar Creek Reservoir and 15% of the measurements in the underlying chlorophyll *a* dataset available for Cedar Creek Reservoir were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is not satisfied in the case of Cedar Creek Reservoir, EPA strongly considered the very high rate of chlorophyll *a* accumulation, relatively speaking, based on EPA's trend analysis (slope = 0.473 µg/L chlorophyll *a*/year) in combination with TCEQ's identification of 20 nutrient concerns that were repeating. These two information sources indicate both the presence of nutrients in concentrations of concern to TCEQ and a biological response in the form of a very high chlorophyll *a* accumulation rate. Additionally, EPA strongly considered the MCL exceedances noted above and the fact that the chlorophyll *a* criterion for Cedar Creek Reservoir and 15% of the measurements in the underlying chlorophyll *a* dataset available for Cedar Creek Reservoir were greater than 30 µg/L. With the latter being the case, EPA is concerned that the chlorophyll *a* criterion (which is derived and expressed as a long-term central tendency), is not likely to protect designated uses from the effects of high instantaneous chlorophyll *a* concentrations (such as nuisance blooms, toxic cyanobacteria and toxin production, taste and odor compound production, and disinfection byproduct production). Based on the above information, EPA concludes that the chlorophyll *a* criterion of 30.40 µg/L applicable to Cedar Creek Reservoir is not protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA disapproves this reservoir-specific chlorophyll *a* criterion.

69. White Rock Lake, Segment 0827, Chlorophyll *a* Criterion 33.65 µg/L (Disapproved)

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 34 measurements collected between between September 13, 1973, and September 24, 2008. Of these 34 measurements, none were considered to be outliers because none had values greater than 71.25 µg/L. So, the criterion was derived using a final dataset consisting of 34 chlorophyll *a* measurements collected between between September 13, 1973, and September 24, 2008, all of which were equal to or below 50 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for White Rock Lake.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for White Rock Lake:

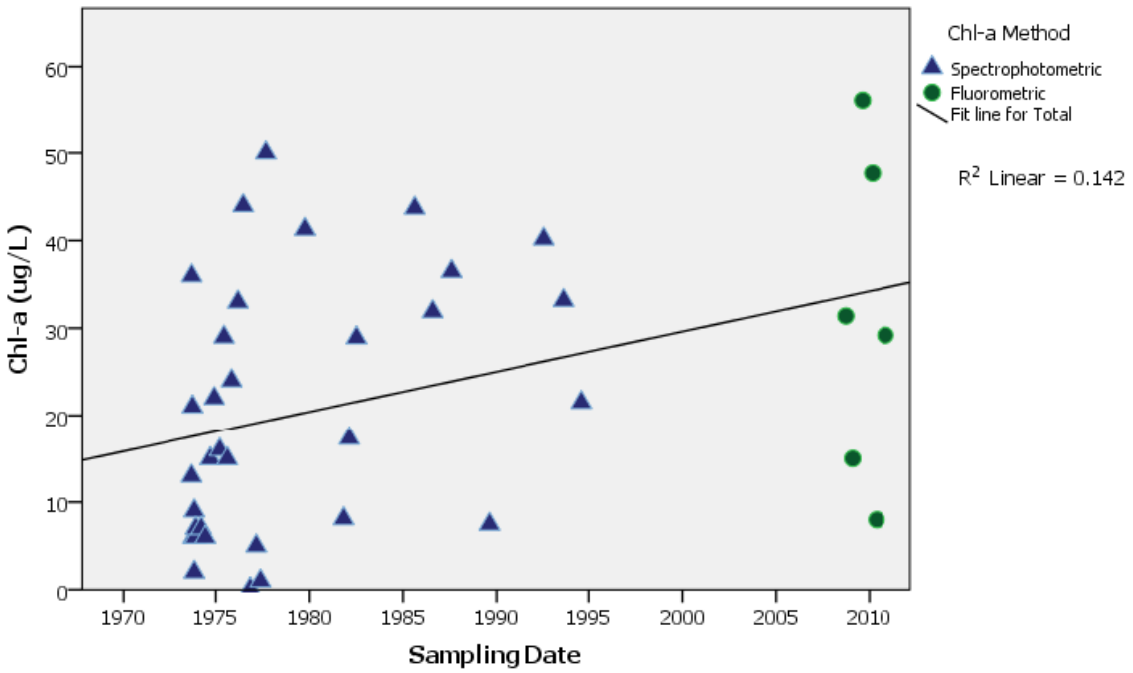
Year	Parameter	Assessment Unit	Assessment Unit Description
2010	NO3-N	0827A_01	From the headwaters of White Rock Lake upstream to the upper end of the water body at NHD RC 12030105001118

Treated Drinking Water Chemical Data: For facilities using source water from White Rock Lake, TCEQ did not report finding any exceedances of SDWA MCLs for any disinfection byproducts or nitrate in supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: White Rock Lake was sampled one time as part of the 2007 NLA. The chlorophyll *a* concentration measured during sampling was 41.76 µg/L, indicating a moderate risk of exposure based on the chlorophyll *a* thresholds used in the NLA study. Microcystin was detected above the reporting limit of 0.1 ug/L at a concentration of 0.21 ug/L, indicating a low risk of exposure based on the microcystin thresholds used in the NLA study. The cyanobacteria cell count during sampling was less than 20,000 cells per milliliter, indicating a low risk of exposure based on the cyanobacteria thresholds used in the NLA study.

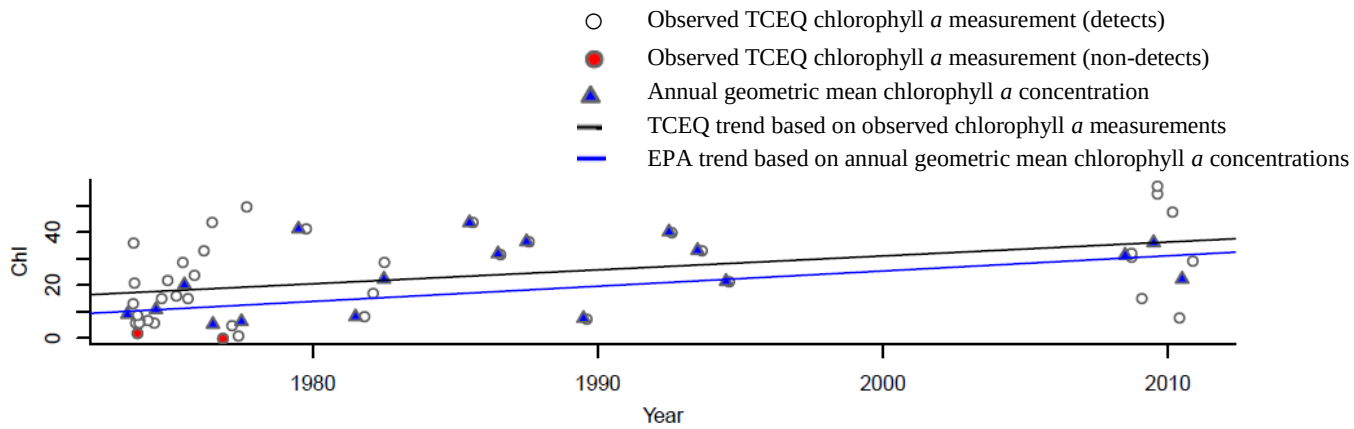
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 39 chlorophyll *a* measurements collected from White Rock Lake between 1973 and 2010 (see Figure 137). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for White Rock Lake. Based upon the supporting information provided by TCEQ, a shift in methodology does appear to have occurred for this dataset in 2008 (with all data after 2008 being collected using the fluorometric method rather than the spectrophotometric method). Thirty-three chlorophyll *a* measurements were made using the spectrophotometric method, with 2 of these measurements (~6%) being reported as less than the minimum reporting limits. Six measurements were made using the fluorometric method, with none of these measurements (0%) being reported as less than the minimum reporting limits. When TCEQ analyzed trends for each of these datasets separately, the chlorophyll *a* data collected using the fluorometic method did not show a statistically significant increasing trend, while the chlorophyll *a* data collected using the spectrophotometric method did show a statistically significant increasing trend. In further analyzing the spectrophotometric method dataset, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) did not affect the statistical significance of this chlorophyll *a* trend to such a degree that the trend became statistically insignificant. Therefore, EPA believes that this increasing trend for White Rock Lake is statistically significant.

Figure 137. Chlorophyll *a* Trend for White Rock Lake Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for White Rock Lake based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 138). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For White Rock Lake, the magnitude of the slope of this increasing trend was very high, relatively speaking, at 0.575 µg/L chlorophyll *a*/year.

Figure 138. Chlorophyll *a* Trends for White Rock Lake Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: White Rock Lake was not included in TCEQ's report titled *Trophic Classification of Texas Reservoirs*.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For White Rock Lake, the chlorophyll *a* criterion is above 30 µg/L and 32% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for White Rock Lake, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is not satisfied in the case of White Rock Lake. Trophic state classification information was not available for White Rock Lake. Reservoir-specific data and information described above indicates a very high rate of chlorophyll *a* accumulation, relatively speaking, based on EPA's trend analysis (slope = 0.575 µg/L chlorophyll *a*/year) and a statistically significant increasing trend in chlorophyll *a* concentration based on EPA's review of TCEQ's trend analysis. TCEQ did not identify any CWA §303(d) listings for pH or DO for White Rock Lake. TCEQ identified only one concern for nutrients (NO3-N) in White Rock Lake in the 2010 reporting cycle. 2007 NLA data for White Rock Lake indicated a moderate risk of exposure based on chlorophyll *a* thresholds and a low risk of exposure based on microcystin and cyanobacteria thresholds. Further, the chlorophyll *a* criterion for White Rock Lake and 32% of the measurements in the underlying chlorophyll *a* dataset available for White Rock Lake were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is not satisfied in the case of White Rock Lake, EPA strongly considered this last information source. With the chlorophyll *a* criterion for White Rock Lake and 32% of the measurements in the underlying chlorophyll *a* dataset available for White Rock Lake being greater than 30 µg/L, EPA is concerned that the chlorophyll *a* criterion (which is derived and expressed as a long-term central tendency), is not likely to

protect designated uses from the effects of high instantaneous chlorophyll *a* concentrations (such as nuisance blooms, toxic cyanobacteria and toxin production, taste and odor compound production, and disinfection byproduct production). Based on the above information, EPA concludes that the chlorophyll *a* criterion of 33.65 µg/L applicable to White Rock Lake is not protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA disapproves this reservoir-specific chlorophyll *a* criterion.

70. Lake Worth, Segment 0807, Chlorophyll *a* Criterion 34.18 µg/L (Disapproved)

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 45 measurements collected between between June 19, 1990, and October 15, 2008. Of these 45 measurements, none were considered to be outliers because none had values greater than 47.4 µg/L. So, the criterion was derived using a final dataset consisting of 45 chlorophyll *a* measurements collected between between June 19, 1990, and October 15, 2008, all of which were equal to or below 47.4 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Lake Worth.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Lake Worth:

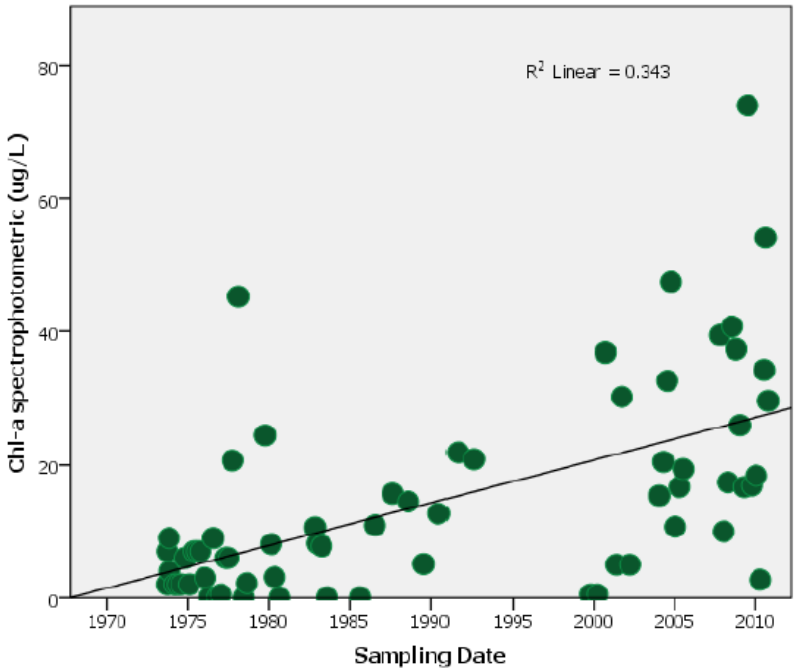
Year	Parameter	Assessment Unit	Assessment Unit Description
2006	Chl-a	0807_01	Entire reservoir
2008	Chl-a	0807_01	Entire reservoir

Treated Drinking Water Chemical Data: For facilities using source water from Lake Worth, TCEQ did not report finding any exceedances of SDWA MCLs for any disinfection byproducts or nitrate in supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Lake Worth was not sampled as part of the 2007 NLA.

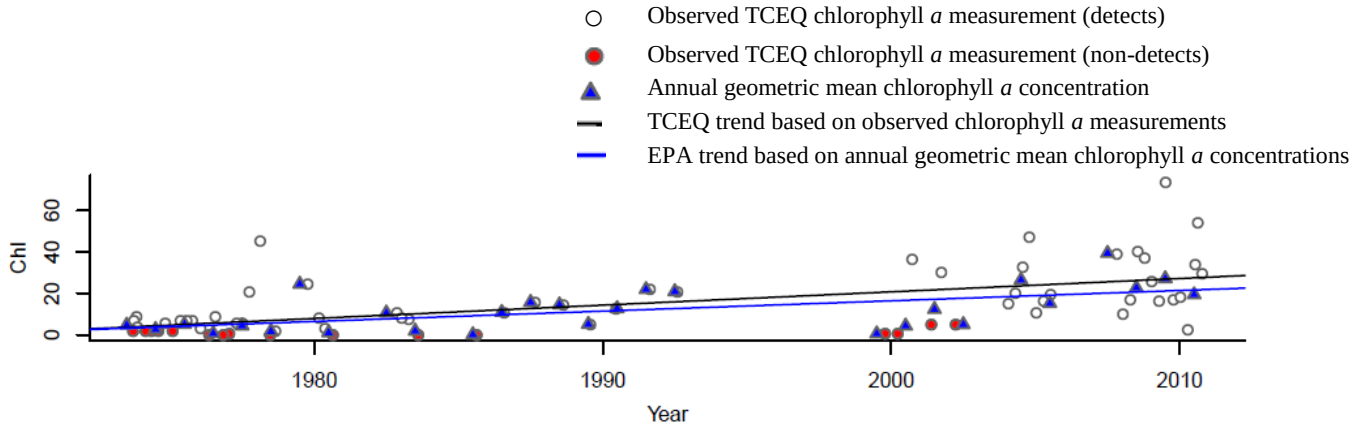
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 66 chlorophyll *a* measurements collected from Lake Worth between 1973 and 2010 (see Figure 139). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Lake Worth. Based upon the supporting information provided by TCEQ, all of these chlorophyll *a* measurements were determined using the same method (spectrophotometric). Sixteen of these 66 measurements (24%) were reported as being less than the reporting limits. In further analyzing the spectrophotometric method dataset, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) did not affect the statistical significance of this chlorophyll *a* trend to such a degree that the trend became statistically insignificant. Therefore, EPA believes that this increasing trend for Lake Worth is statistically significant.

Figure 139. Chlorophyll *a* Trend for Lake Worth Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Lake Worth based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 140). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Lake Worth, the magnitude of the slope of this increasing trend was very high, relatively speaking, at 0.499 µg/L chlorophyll *a*/year.

Figure 140. Chlorophyll *a* Trends for Lake Worth Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Lake Worth was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Lake Worth between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 55.78 was determined for the 2010 reporting cycle for Lake Worth. This value was

based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 0.04 points lower than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Lake Worth was hypereutrophic for both the 2000 and 2010 reporting cycles.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Lake Worth, the chlorophyll *a* criterion is above 30 µg/L and 14% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Lake Worth, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is not satisfied in the case of Lake Worth. Reservoir-specific data and information described above indicates a hypereutrophic classification for Lake Worth, with a very high rate of chlorophyll *a* accumulation, relatively speaking, based on EPA's trend analysis (slope = 0.499 µg/L chlorophyll *a*/year) and a statistically significant increasing trend in chlorophyll *a* concentration based on EPA's review of TCEQ's trend analysis. TCEQ did not identify any CWA §303(d) listings for pH or DO for Lake Worth. While TCEQ did not identify any nutrient concerns in Lake Worth, TCEQ did identify two concerns for chlorophyll *a* in the 2006 through 2008 reporting cycles. Further, the chlorophyll *a* criterion for Lake Worth and 14% of the measurements in the underlying chlorophyll *a* dataset available for Lake Worth were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is not satisfied in the case of Lake Worth, EPA not only strongly considered the reservoir's hypereutrophic classification in the 2000 and 2010 reporting cycles, but also strongly considered the fact that the chlorophyll *a* criterion for Lake Worth and 14% of the measurements in the underlying chlorophyll *a* dataset available for Lake Worth were greater than 30 µg/L. With this being the case, EPA is concerned that the chlorophyll *a* criterion (which is derived and expressed as a long-term central tendency), is not likely to protect designated uses from the effects of high instantaneous chlorophyll *a* concentrations (such as nuisance blooms, toxic cyanobacteria and toxin production, taste and odor compound production, and disinfection byproduct production). Based on the above information, EPA concludes that the chlorophyll *a* criterion of 34.18 µg/L applicable to Lake Worth is not protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA disapproves this reservoir-specific chlorophyll *a* criterion.

71. <u>Lake Tawakoni, Segment 0507, Chlorophyll *a* Criterion 37.18 µg/L (Disapproved)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 144 measurements collected between between March 12, 1990, and November 11, 2008. Of these 144 measurements, 1 was considered to be an outlier because it had a value greater than 74.8125 µg/L. So, the criterion was derived using a final dataset consisting of 143 chlorophyll *a* measurements collected between between March 12, 1990, and November 11, 2008, all of which were equal to or below 74.5 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for pH and DO listings in the 2000 through 2010 reporting cycles, the following 303(d) listings were identified for Lake Tawakoni:

Year	Parameter	Assessment Unit	Assessment Unit Description
2000	DO	n/a	Area near the dam
2002	DO	n/a	Lowermost 5,120 acres of reservoir, adjacent to dam
2004	DO	n/a	Lowermost 5,120 acres of reservoir, adjacent to dam
2000	high pH	n/a	Cowleech Fork arm
2008	pH	0507_04	Cowleech Fork of Sabine River Arm
2010	pH	0507_04	Cowleech Fork of Sabine River Arm
2000	high pH	n/a	Kitsee Inlet arm

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Lake Tawakoni:

Year	Parameter	Assessment Unit	Assessment Unit Description
2006	Chl-a	0507_01	Lowermost 5,120 acres of reservoir, adjacent to dam
2008	Chl-a	0507_01	Lowermost 5,120 acres of reservoir, adjacent to dam
2010	Chl-a	0507_01	Lowermost area of reservoir, adjacent to dam
2006	Chl-a	0507_02	Kitsee Inlet
2008	Chl-a	0507_02	Kitsee Inlet
2010	Chl-a	0507_02	Middle of reservoir near Spring Point
2006	OP	0507_02	Kitsee Inlet
2008	OP	0507_02	Kitsee Inlet
2010	Chl-a	0507_03	Upper middle body of lake near SH 276
2006	DO	0507_03	South Fork of Sabine River cove
2008	DO	0507_03	South Fork of Sabine River cove
2006	Chl-a	0507_04	Cowleech Fork of Sabine River arm
2008	Chl-a	0507_04	Cowleech Fork of Sabine River arm
2010	Chl-a	0507_04	Cowleech Fork of Sabine River arm
2008	Chl-a	0507_05	5120 acres near SH 276
2010	Chl-a	0507_05	South Fork of the Sabine River around Kitsee Inlet
2010	OP	0507_05	South Fork of the Sabine River around Kitsee Inlet
2008	Chl-a	0507_06	5120 acres near Spring Point

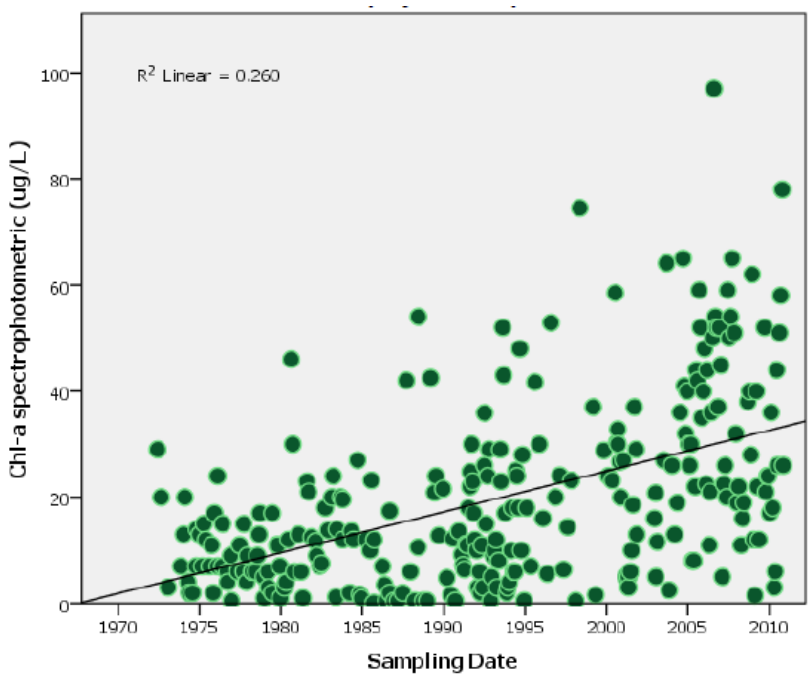
Treated Drinking Water Chemical Data: In supporting documentation provided to EPA on February 24, 2012, TCEQ identified one facility using source water from Lake Tawakoni which reported periodic occurrences of haloacetic acids above the SDWA MCL.

2007 National Lakes Assessment Data: Lake Tawakoni was not sampled as part of the 2007 NLA.

TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 273 chlorophyll *a* measurements collected from Lake Tawakoni between 1972 and 2010 (see Figure 141). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Lake Tawakoni. Based upon the supporting information provided by TCEQ, all of these chlorophyll *a* measurements were determined using the same method (spectrophotometric). Twenty-one of these 273 measurements (8%) were reported as being less than the reporting limits. In further analyzing the spectrophotometric method dataset, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) did not affect the statistical significance of this chlorophyll *a* trend to such a

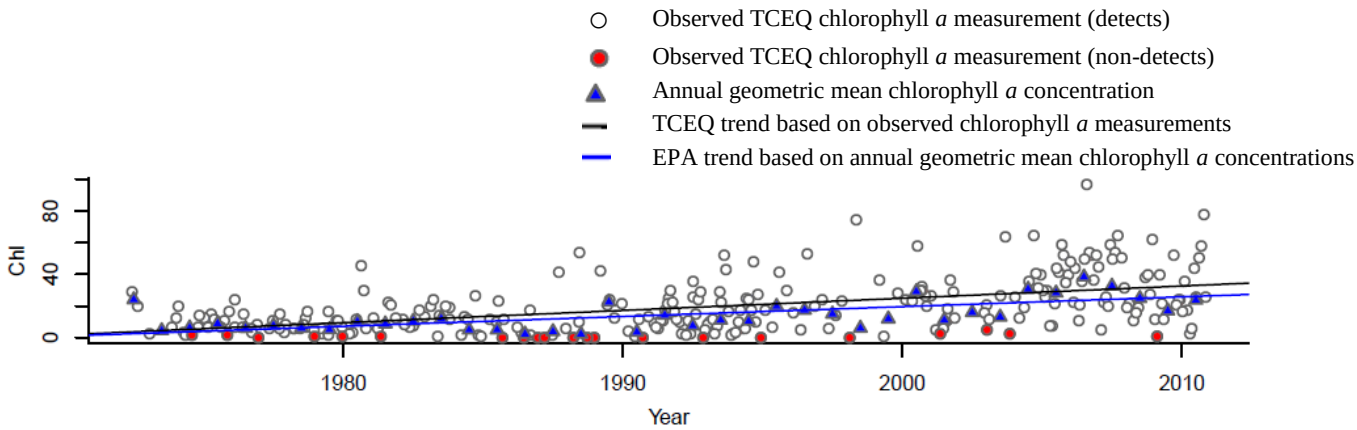
degree that the trend became statistically insignificant. Therefore, EPA believes that this increasing trend for Lake Tawakoni is statistically significant.

Figure 141. Chlorophyll *a* Trend for Lake Tawakoni Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Lake Tawakoni based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 142). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Lake Tawakoni, the magnitude of the slope of this increasing trend was very high, relatively speaking, at 0.619 µg/L chlorophyll *a*/year.

Figure 142. Chlorophyll *a* Trends for Lake Tawakoni Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Lake Tawakoni was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting

cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Lake Tawakoni between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 64.38 was determined for the 2010 reporting cycle for Lake Tawakoni. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 10.13 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Lake Tawakoni shifted from a eutrophic classification for the 2000 reporting cycle to a hypereutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Lake Tawakoni, the chlorophyll *a* criterion is above 30 µg/L and 19% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Lake Tawakoni, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is not satisfied in the case of Lake Tawakoni. Reservoir-specific data and information described above indicates a eutrophic classification for Lake Tawakoni in the 2000 reporting cycle with a shift to a hypereutrophic classification in the 2010 reporting cycle. Reservoir-specific data and information described above indicates a very high rate of chlorophyll *a* accumulation, relatively speaking, based on EPA's trend analysis (slope = 0.619 µg/L chlorophyll *a*/year) and a statistically significant increasing trend in chlorophyll *a* concentration based on EPA's review of TCEQ's trend analysis. TCEQ identified seven CWA §303(d) listings for DO and pH in Lake Tawakoni in the 2000 through 2004 and 2008 through 2010 reporting cycles. TCEQ identified 15 concerns for chlorophyll *a* and DO in Lake Tawakoni in the 2006 through 2010 reporting cycles. And, though not considered repeating (as previously defined in Footnote 2), TCEQ identified three nutrient concerns (OP) in the 2006 through 2010 reporting cycles in Lake Tawakoni. TCEQ identified one facility using source water from Lake Tawakoni which reported periodic occurrences of haloacetic acids above the SDWA MCL. Further, the chlorophyll *a* criterion for Lake Tawakoni and 19% of the measurements in the underlying chlorophyll *a* dataset available for Lake Tawakoni were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is not satisfied in the case of Lake Tawakoni, EPA not only strongly considered the shift to a hypereutrophic classification in the 2010 reporting cycle and the MCL exceedances noted above, but also strongly considered the fact that the chlorophyll *a* criterion for Lake Tawakoni and 19% of the measurements in the underlying chlorophyll *a* dataset available for Lake Tawakoni were greater than 30 µg/L. With this being the case, EPA is concerned that the chlorophyll *a* criterion (which is derived and expressed as a long-term central tendency), is not likely to protect designated uses from the effects of high instantaneous chlorophyll *a* concentrations (such as nuisance blooms, toxic cyanobacteria and toxin production, taste and odor compound production, and disinfection byproduct production). Based on the above information, EPA concludes that the chlorophyll *a* criterion of 37.18 µg/L applicable to Lake Tawakoni is not protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA disapproves this reservoir-specific chlorophyll *a* criterion.

72. <u>O.C. Fisher Lake, Segment 1425, Chlorophyll *a* Criterion 39.13 µg/L (Disapproved)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 35 measurements collected between between June 28, 1990, and December 10, 2008. Of these 35 measurements, 2 were considered to be outliers because they had values greater

than 86.2075 µg/L. So, the criterion was derived using a final dataset consisting of 33 chlorophyll *a* measurements collected between between June 28, 1990, and December 10, 2008, all of which were equal to or below 56 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for O.C. Fisher Lake.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for O.C. Fisher Lake:

Year	Parameter	Assessment Unit	Assessment Unit Description
2006	Chl-a	1425_01	Entire water body
2008	Chl-a	1425_01	Entire water body
2010	Chl-a	1425_01	Entire water body
2010	DO	1425_01	Entire water body
2006	NH3-N	1425_01	Entire water body
2008	NH3-N	1425_01	Entire water body
2010	NH3-N	1425_01	Entire water body
2006	NO3-N	1425_01	Entire water body
2006	OP	1425_01	Entire water body
2008	OP	1425_01	Entire water body
2010	OP	1425_01	Entire water body
2006	TP	1425_01	Entire water body
2008	TP	1425_01	Entire water body

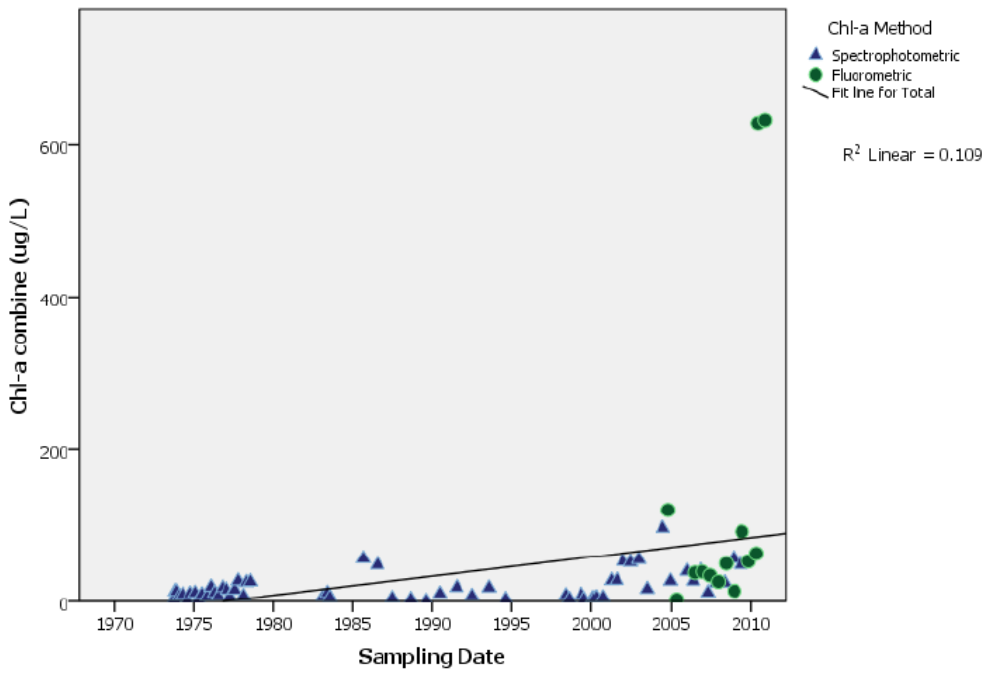
Treated Drinking Water Chemical Data: For facilities using source water from O.C. Fisher Lake, TCEQ did not report finding any exceedances of SDWA MCLs for any disinfection byproducts or nitrate in supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: O.C. Fisher Lake was sampled one time as part of the 2007 NLA. The chlorophyll *a* concentration measured during sampling was 12.58 µg/L, indicating a moderate risk of exposure based on the chlorophyll *a* thresholds used in the NLA study. The microcystin concentration during sampling was below the reporting limit of 0.1 µg/L, indicating a low risk of exposure based on the microcystin thresholds used in the NLA study. The cyanobacteria cell count during sampling was between 20,000 and 100,000 cells per milliliter, indicating a moderate risk of exposure based on the cyanobacteria thresholds used in the NLA study.

TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 72 chlorophyll *a* measurements collected from O.C. Fisher Lake between 1973 and 2010 (see Figure 143). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for O.C. Fisher Lake. Based upon the supporting information provided by TCEQ, a shift in methodology does appear to have occurred for this dataset in 2004 (with some data after 2004 being collected using the fluorometric method rather than the spectrophotometric method). Fifty-nine chlorophyll *a* measurements were made using the spectrophotometric method, with 6 of these measurements (~10%) being reported as less than the minimum reporting limits. Thirteen measurements

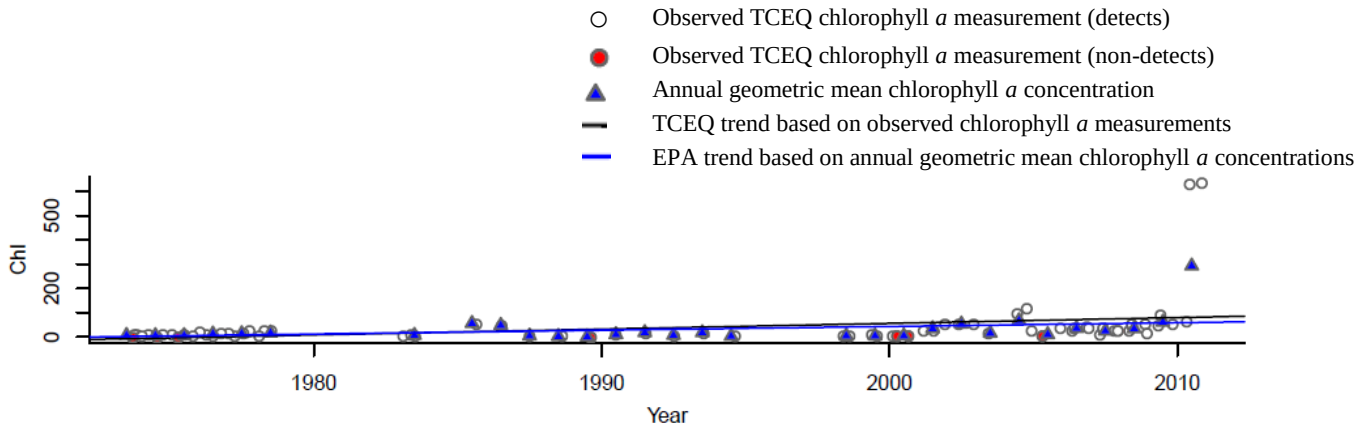
were made using the fluorometric method, with 1 of these measurements (8%) being reported as less than the minimum reporting limits. When TCEQ analyzed trends for each of these datasets separately, the chlorophyll *a* data collected using the fluorometic method did not show a statistically significant increasing trend, while the chlorophyll *a* data collected using the spectrophotometric method did show a statistically significant increasing trend. In further analyzing the spectrophotometric method dataset, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) did not affect the statistical significance of this chlorophyll *a* trend to such a degree that the trend became statistically insignificant. Therefore, EPA believes that this increasing trend for O.C. Fisher Lake is statistically significant.

Figure 143. Chlorophyll *a* Trend for O.C. Fisher Lake Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for O.C. Fisher Lake based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 144). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For O.C. Fisher Lake, the magnitude of the slope of this increasing trend was very high, relatively speaking, at 1.550 µg/L chlorophyll *a*/year.

Figure 144. Chlorophyll *a* Trends for O.C. Fisher Lake Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: O.C. Fisher Lake was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for O.C. Fisher Lake between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 63.98 was determined for the 2010 reporting cycle for O.C. Fisher Lake. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 15.14 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that O.C. Fisher Lake shifted from a eutrophic classification for the 2000 reporting cycle to a hypereutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For O.C. Fisher Lake, the chlorophyll *a* criterion is above 30 µg/L and 21% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for O.C. Fisher Lake, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is not satisfied in the case of O.C. Fisher Lake. Reservoir-specific data and information described above indicates a eutrophic classification for O.C. Fisher Lake in the 2000 reporting cycle with a shift to a hypereutrophic classification in the 2010 reporting cycle. Reservoir-specific data and information described above indicates a very high rate of chlorophyll *a* accumulation, relatively speaking, based on EPA's trend analysis (slope = 1.550 µg/L chlorophyll *a*/year) and a statistically significant increasing trend in chlorophyll *a* concentration based on EPA's review of TCEQ's trend analysis. TCEQ did not identify any CWA §303(d) listings for pH or DO for O.C. Fisher Lake. However, TCEQ did identify four concerns for chlorophyll *a* and DO in O.C. Fisher Lake in the 2006 through 2010 reporting cycles, as well as nine concerns for nutrients (NH3-N, NO3-N, OP and TP) in O.C. Fisher Lake that were repeating. 2007 NLA data for O.C. Fisher Lake indicated a moderate risk of exposure based on chlorophyll *a* and cyanobacteria thresholds and a low risk of exposure based on microcystin thresholds. Further, the chlorophyll *a* criterion for O.C. Fisher Lake and 21% of the measurements in the underlying chlorophyll *a* dataset available for O.C. Fisher Lake were greater than 30

µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is not satisfied in the case of O.C. Fisher Lake, EPA not only strongly considered the shift to a hypereutrophic classification in the 2010 reporting cycle, but also strongly considered the very high rate of chlorophyll *a* accumulation, relatively speaking, based on EPA's trend analysis (slope = 1.550 µg/L chlorophyll *a*/year) in combination with TCEQ's identification of nine nutrient concerns that were repeating. These latter two information sources indicate both the presence of nutrients in concentrations of concern to TCEQ and a biological response in the form of a very high chlorophyll *a* accumulation rate. Additionally, EPA strongly considered the fact that the chlorophyll *a* criterion for O.C. Fisher Lake and 21% of the measurements in the underlying chlorophyll *a* dataset available for O.C. Fisher Lake were greater than 30 µg/L. With this being the case, EPA is concerned that the chlorophyll *a* criterion (which is derived and expressed as a long-term central tendency), is not likely to protect designated uses from the effects of high instantaneous chlorophyll *a* concentrations (such as nuisance blooms, toxic cyanobacteria and toxin production, taste and odor compound production, and disinfection byproduct production). Based on the above information, EPA concludes that the chlorophyll *a* criterion of 39.13 µg/L applicable to O.C. Fisher Lake is not protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA disapproves this reservoir-specific chlorophyll *a* criterion.

73. Lake Tanglewood, Segment 0229, Chlorophyll *a* Criterion 43.71 µg/L (Disapproved)

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 49 measurements collected between between June 21, 1995, and October 30, 2008. Of these 49 measurements, 3 were considered to be outliers because they had values greater than 95.5 µg/L. So, the criterion was derived using a final dataset consisting of 46 chlorophyll *a* measurements collected between between June 21, 1995, and October 30, 2008, all of which were equal to or below 81.3 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Lake Tanglewood.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Lake Tanglewood:

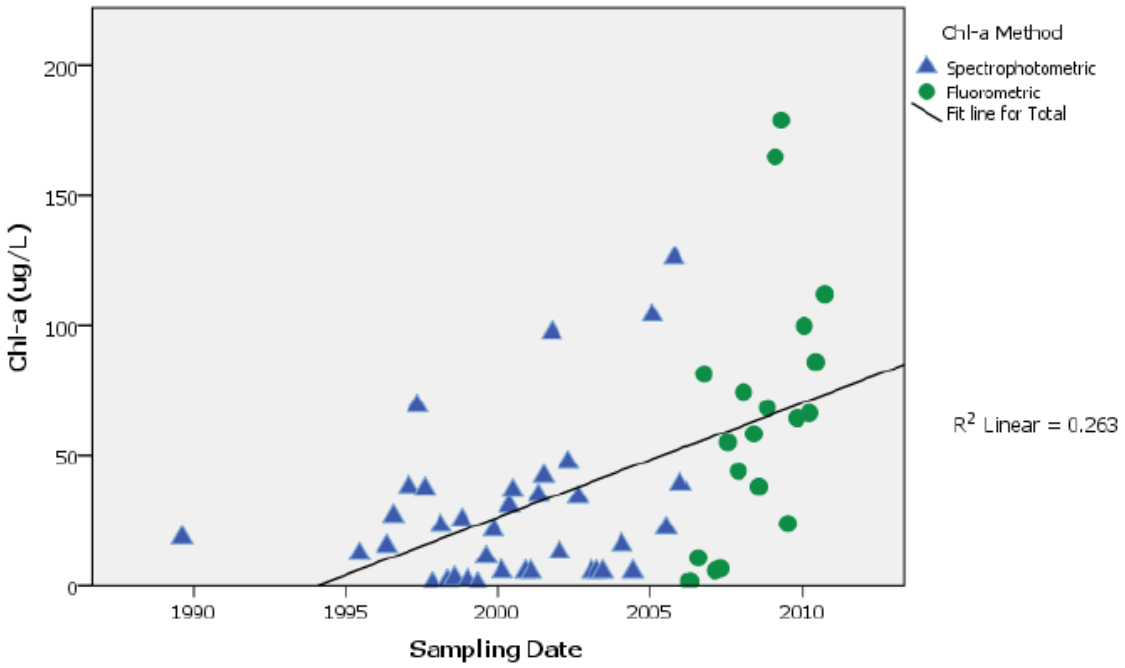
Year	Parameter	Assessment Unit	Assessment Unit Description
2006	Chl-a	0229A_01	Entire lake
2008	Chl-a	0229A_01	Entire lake
2010	Chl-a	0229A_01	Entire lake
2010	DO	0229A_01	Entire lake
2010	NH3-N	0229A_01	Entire lake
2006	NO3-N	0229A_01	Entire lake
2008	NO3-N	0229A_01	Entire lake
2010	NO3-N	0229A_01	Entire lake
2006	OP	0229A_01	Entire lake
2008	OP	0229A_01	Entire lake
2010	OP	0229A_01	Entire lake
2006	TP	0229A_01	Entire lake
2008	TP	0229A_01	Entire lake
2010	TP	0229A_01	Entire lake

Treated Drinking Water Chemical Data: For facilities using source water from Lake Tanglewood, TCEQ did not report finding any exceedances of SDWA MCLs for any disinfection byproducts or nitrate in supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Lake Tanglewood was not sampled as part of the 2007 NLA.

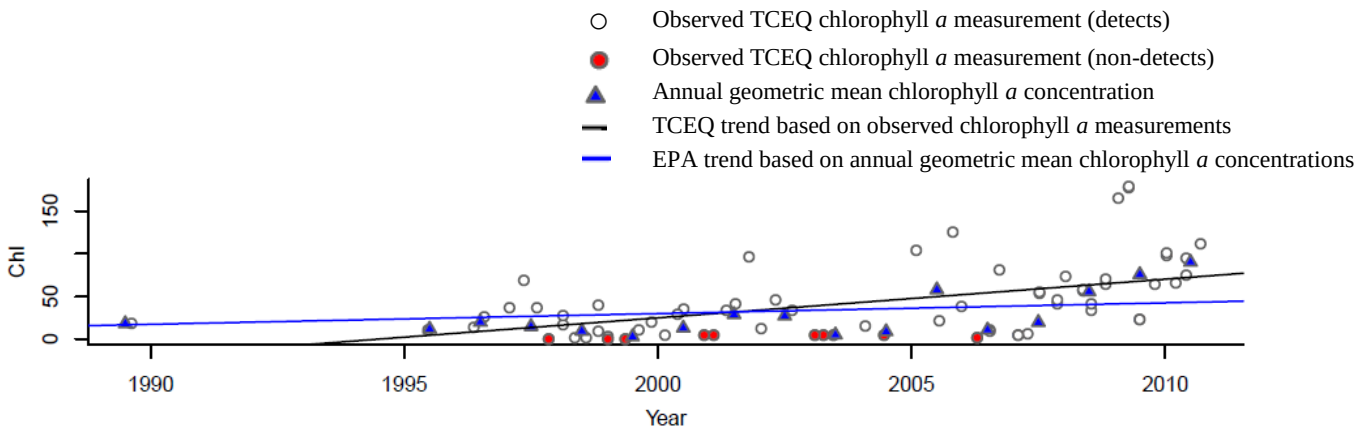
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 55 chlorophyll *a* measurements collected from Lake Tanglewood between 1989 and 2010 (see Figure 145). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Lake Tanglewood. Based upon the supporting information provided by TCEQ, a shift in methodology does appear to have occurred for this dataset in 2006 (with all data after 2006 being collected using the fluorometric method rather than the spectrophotometric method). Thirty-six chlorophyll *a* measurements were made using the spectrophotometric method, with 9 of these measurements (25%) being reported as less than the minimum reporting limits. Nineteen measurements were made using the fluorometric method, with 1 of these measurements (5%) being reported as less than the minimum reporting limits. When TCEQ analyzed trends for each of these datasets separately, the chlorophyll *a* data collected using the spectrophotometric method did not show a statistically significant increasing trend, while the chlorophyll *a* data collected using the fluorometic method did show a statistically significant increasing trend. In further analyzing the fluorometric method dataset, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) did not affect the statistical significance of this chlorophyll *a* trend to such a degree that the trend became statistically insignificant. Therefore, EPA believes that this increasing trend for Lake Tanglewood is statistically significant.

Figure 145. Chlorophyll *a* Trend for Lake Tanglewood Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Lake Tanglewood based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 146). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Lake Tanglewood, the magnitude of the slope of this increasing trend was very high, relatively speaking, at 1.256 µg/L chlorophyll *a*/year.

Figure 146. Chlorophyll *a* Trends for Lake Tanglewood Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Lake Tanglewood was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Lake Tanglewood between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 63.46 was determined for the 2010 reporting cycle for Lake Tanglewood. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 10.58 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Lake Tanglewood shifted from a eutrophic classification for the 2000 reporting cycle to a hypereutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Lake Tanglewood, the chlorophyll *a* criterion is above 30 µg/L and 43% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Lake Tanglewood, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is not satisfied in the case of Lake Tanglewood. Reservoir-specific data and information described above indicates a eutrophic classification for Lake Tanglewood in the 2000 reporting cycle with a shift to a hypereutrophic classification in the 2010 reporting cycle. Reservoir-specific data and information described above indicates a very high rate of chlorophyll *a* accumulation, relatively speaking, based on EPA's trend analysis (slope = 1.256 µg/L chlorophyll *a*/year) and a statistically significant increasing trend in chlorophyll *a* concentration based on EPA's review of TCEQ's

trend analysis. TCEQ did not identify any CWA §303(d) listings for pH or DO for Lake Tanglewood. However, TCEQ did identify four concerns for chlorophyll *a* and DO in Lake Tanglewood in the 2006 through 2010 reporting cycles, as well as ten concerns for nutrients (NH3-N, NO3-N, OP and TP) in Lake Tanglewood that were repeating. Further, the chlorophyll *a* criterion for Lake Tanglewood and 43% of the measurements in the underlying chlorophyll *a* dataset available for Lake Tanglewood were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is not satisfied in the case of Lake Tanglewood, EPA not only strongly considered the shift to a hypereutrophic classification in the 2010 reporting cycle, but also strongly considered the very high rate of chlorophyll *a* accumulation, relatively speaking, based on EPA's trend analysis (slope = 1.256 µg/L chlorophyll *a*/year) in combination with TCEQ's identification of ten nutrient concerns that were repeating. These latter two information sources indicate both the presence of nutrients in concentrations of concern to TCEQ and a biological response in the form of a very high chlorophyll *a* accumulation rate. Additionally, EPA strongly considered the fact that the chlorophyll *a* criterion for Lake Tanglewood and 43% of the measurements in the underlying chlorophyll *a* dataset available for Lake Tanglewood were greater than 30 µg/L. With this being the case, EPA is concerned that the chlorophyll *a* criterion (which is derived and expressed as a long-term central tendency), is not likely to protect designated uses from the effects of high instantaneous chlorophyll *a* concentrations (such as nuisance blooms, toxic cyanobacteria and toxin production, taste and odor compound production, and disinfection byproduct production). Based on the above information, EPA concludes that the chlorophyll *a* criterion of 43.71 µg/L applicable to Lake Tanglewood is not protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA disapproves this reservoir-specific chlorophyll *a* criterion.

74. <u>Somerville Lake, Segment 1212, Chlorophyll *a* Criterion 53.05 µg/L (Disapproved)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 53 measurements collected between between July 31, 1990, and November 18, 2008. Of these 53 measurements, none were considered to be outliers because none had values greater than 102.35 µg/L. So, the criterion was derived using a final dataset consisting of 53 chlorophyll *a* measurements collected between between July 31, 1990, and November 18, 2008, all of which were equal to or below 87.4 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for pH and DO listings in the 2000 through 2010 reporting cycles, the following 303(d) listings were identified for Somerville Lake:

Year	Parameter	Assessment Unit	Assessment Unit Description
2008	DO	1212_01	Eastern end of reservoir near dam
2010	DO	1212_01	Eastern end of reservoir near dam
2002	low and high pH	n/a	Eastern end of reservoir near dam
2004	low and high pH	n/a	Eastern end of reservoir near dam
2006	pH	1212_01	Eastern end of reservoir near dam
2008	pH	1212_01	Eastern end of reservoir near dam
2010	pH	1212_01	Eastern end of reservoir near dam
2006	pH	1212_03	Middle of reservoir near Birch Creek State Park
2008	pH	1212_03	Middle of reservoir near Birch Creek State Park
2010	pH	1212_03	Middle of reservoir near Birch Creek State Park
2010	pH	1212_04	Western end of reservoir near upper segment boundary

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles,

the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Somerville Lake:

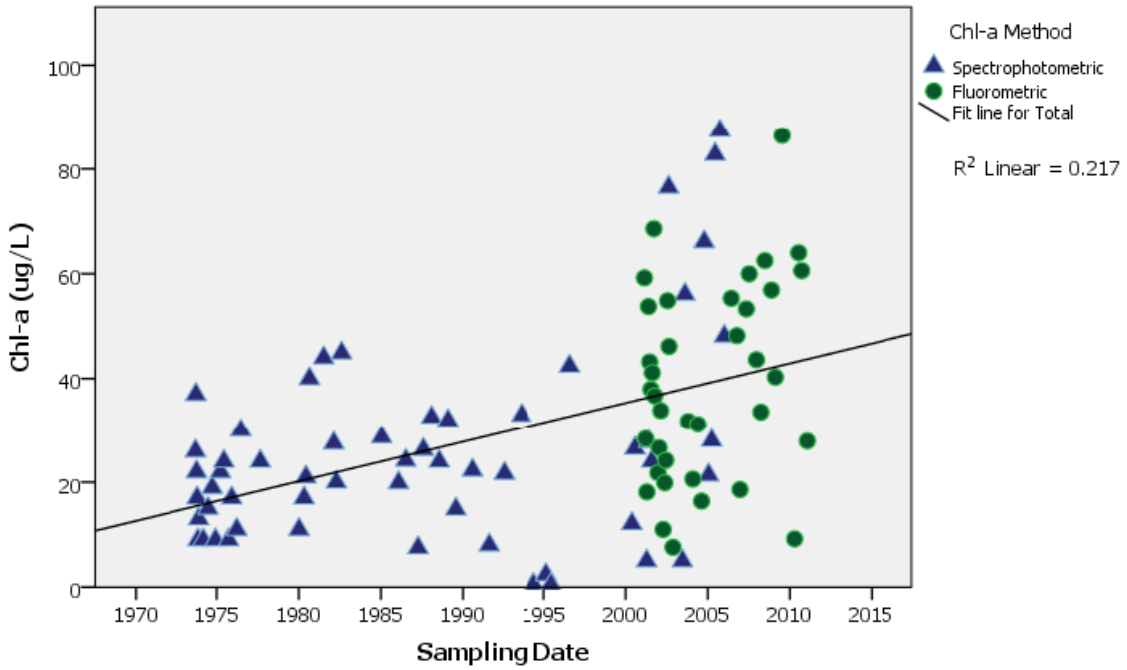
Year	Parameter	Assessment Unit	Assessment Unit Description
2006	Chl-a	1212_01	Eastern end of reservoir near dam
2008	Chl-a	1212_01	Eastern end of reservoir near dam
2010	Chl-a	1212_01	Eastern end of reservoir near dam
2006	DO	1212_01	Eastern end of reservoir near dam
2010	HAB/GA	1212_01	Eastern end of reservoir near dam
2010	HAB/GA	1212_02	Northern arm of reservoir near town of Somerville
2006	Chl-a	1212_03	Middle of reservoir near Birch Creek State Park
2008	Chl-a	1212_03	Middle of reservoir near Birch Creek State Park
2010	Chl-a	1212_03	Middle of reservoir near Birch Creek State Park
2006	Chl-a	1212_04	Western end of reservoir near upper segment boundary
2008	Chl-a	1212_04	Western end of reservoir near upper segment boundary
2010	Chl-a	1212_04	Western end of reservoir near upper segment boundary
2010	HAB/GA	1212_04	Western end of reservoir near upper segment boundary

Treated Drinking Water Chemical Data: For facilities using source water from Somerville Lake, TCEQ did not report finding any exceedances of SDWA MCLs for any disinfection byproducts or nitrate in supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Somerville Lake was sampled one time as part of the 2007 NLA. The chlorophyll *a* concentration measured during sampling was 50.26 µg/L, indicating a high risk of exposure based on the chlorophyll *a* thresholds used in the NLA study. The microcystin concentration during sampling was below the reporting limit of 0.1 µg/L, indicating a low risk of exposure based on the microcystin thresholds used in the NLA study. The cyanobacteria cell count during sampling was between 20,000 and 100,000 cells per milliliter, indicating a moderate risk of exposure based on the cyanobacteria thresholds used in the NLA study.

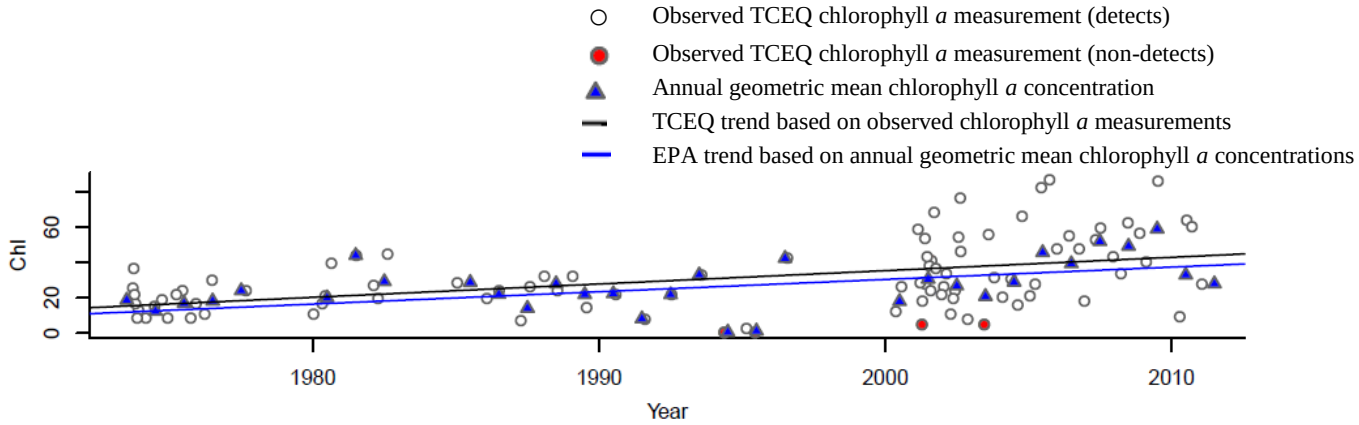
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 93 chlorophyll *a* measurements collected from Somerville Lake between 1973 and 2011 (see Figure 147). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Somerville Lake. Based upon the supporting information provided by TCEQ, a shift in methodology does appear to have occurred for this dataset in 2001 (with some data after 2001 being collected using the fluorometric method rather than the spectrophotometric method). Fifty-six chlorophyll *a* measurements were made using the spectrophotometric method, with 4 of these measurements (~7%) being reported as less than the minimum reporting limits. Thirty-seven measurements were made using the fluorometric method, with none of these measurements (0%) being reported as less than the minimum reporting limits. When TCEQ analyzed trends for each of these datasets separately, the chlorophyll *a* data collected using the fluorometic method did not show a statistically significant increasing trend, while the chlorophyll *a* data collected using the spectrophotometric method did show a statistically significant increasing trend. In further analyzing the spectrophotometric method dataset, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) did not affect the statistical significance of this chlorophyll *a* trend to such a degree that the trend became statistically insignificant. Therefore, EPA believes that this increasing trend for Somerville Lake is statistically significant.

Figure 147. Chlorophyll *a* Trend for Somerville Lake Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Somerville Lake based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 148). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Somerville Lake, the magnitude of the slope of this increasing trend was very high, relatively speaking, at 0.699 µg/L chlorophyll *a*/year.

Figure 148. Chlorophyll *a* Trends for Somerville Lake Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Somerville Lake was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Somerville Lake between the 2000 and 2010 reporting cycles. According to the report, a

Carlson's TSI value of 67.3 was determined for the 2010 reporting cycle for Somerville Lake. This value was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 15.93 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Somerville Lake shifted from a eutrophic classification for the 2000 reporting cycle to a hypereutrophic classification for the 2010 reporting cycle.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Somerville Lake, the chlorophyll *a* criterion is above 30 µg/L and 39% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Somerville Lake, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is not satisfied in the case of Somerville Lake. Reservoir-specific data and information described above indicates a eutrophic classification for Somerville Lake in the 2000 reporting cycle with a shift to a hypereutrophic classification in the 2010 reporting cycle. Reservoir-specific data and information described above indicates a very high rate of chlorophyll *a* accumulation, relatively speaking, based on EPA's trend analysis (slope = 0.699 µg/L chlorophyll *a*/year) and a statistically significant increasing trend in chlorophyll *a* concentration based on EPA's review of TCEQ's trend analysis. TCEQ identified 11 CWA §303(d) listings for DO and pH in Somerville Lake in the 2002 through 2010 reporting cycles. TCEQ also identified 13 concerns for chlorophyll *a*, DO, and HAB/GA in Somerville Lake in the 2006 through 2010 reporting cycles. 2007 NLA data for Somerville Lake indicated a high risk of exposure based on chlorophyll *a* thresholds, a low risk of exposure based on microcystin thresholds, and a moderate risk of exposure based on cyanobacteria thresholds. Further, the chlorophyll *a* criterion for Somerville Lake and 39% of the measurements in the underlying chlorophyll *a* dataset available for Somerville Lake were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is not satisfied in the case of Somerville Lake, EPA not only strongly considered the shift to a hypereutrophic classification in the 2010 reporting cycle and the HAB/GA concerns noted above, but also strongly considered the fact that the chlorophyll *a* criterion for Somerville Lake and 39% of the measurements in the underlying chlorophyll *a* dataset available for Somerville Lake were greater than 30 µg/L. With this being the case, EPA is concerned that the chlorophyll *a* criterion (which is derived and expressed as a long-term central tendency), is not likely to protect designated uses from the effects of high instantaneous chlorophyll *a* concentrations (such as nuisance blooms, toxic cyanobacteria and toxin production, taste and odor compound production, and disinfection byproduct production). Based on the above information, EPA concludes that the chlorophyll *a* criterion of 53.05 µg/L applicable to Somerville Lake is not protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA disapproves this reservoir-specific chlorophyll *a* criterion.

75. <u>Murval Lake, Segment 0509, Chlorophyll *a* Criterion 55.80 µg/L (Disapproved)</u>

Description of Chlorophyll a Dataset: The chlorophyll *a* dataset that TCEQ considered for criteria derivation purposes included 40 measurements collected between between August 16, 1990, and November 6, 2008. Of these 40 measurements, none were considered to be outliers because none had values greater than 93.325 µg/L. So, the criterion was derived using a final dataset consisting of 40 chlorophyll *a* measurements collected between between August 16, 1990, and November 6, 2008, all of which were equal to or below 87.4 µg/L.

CWA § 303(d) Impairment Listings for Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §303(d) lists for the 2000 through 2010 reporting cycles, no 303(d) listings for DO or pH were identified for Murval Lake.

Water Quality "Concerns" for Nutrients and Nutrient Enrichment-related Indicators: In reviewing Texas's CWA §305(b)/303(d) water quality integrated reports for the 2006 through 2010 reporting cycles, the following nutrient and/or nutrient enrichment-related indicator concerns were identified for Murval Lake:

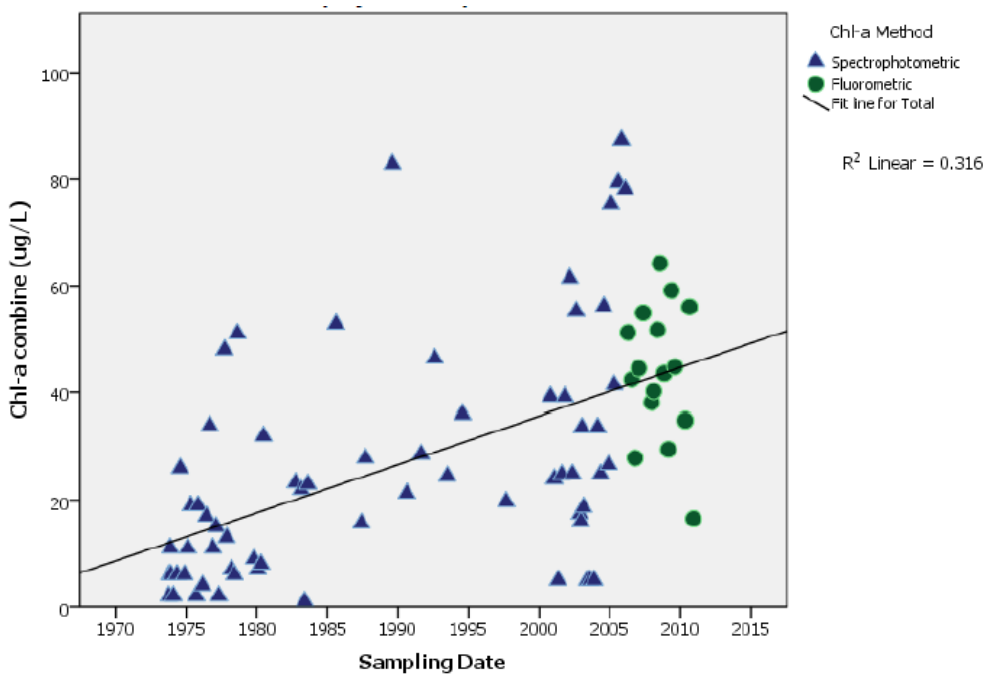
Year	Parameter	Assessment Unit	Assessment Unit Description
2006	Chl-a	0509_01	Entire reservoir
2008	Chl-a	0509_01	Entire reservoir
2010	Chl-a	0509_01	Entire reservoir
2008	OP	0509_01	Entire reservoir

Treated Drinking Water Chemical Data: For facilities using source water from Murval Lake, TCEQ did not report finding any exceedances of SDWA MCLs for any disinfection byproducts or nitrate in supporting documentation provided to EPA on February 24, 2012.

2007 National Lakes Assessment Data: Murval Lake was sampled one time as part of the 2007 NLA. The chlorophyll *a* concentration measured during sampling was 109.83 µg/L, indicating a high risk of exposure based on the chlorophyll *a* thresholds used in the NLA study. The microcystin concentration during sampling was below the reporting limit of 0.1 µg/L, indicating a low risk of exposure based on the microcystin thresholds used in the NLA study. The cyanobacteria cell count during sampling was greater than 100,000 cells per milliliter, indicating a high risk of exposure based on the cyanobacteria thresholds used in the NLA study.

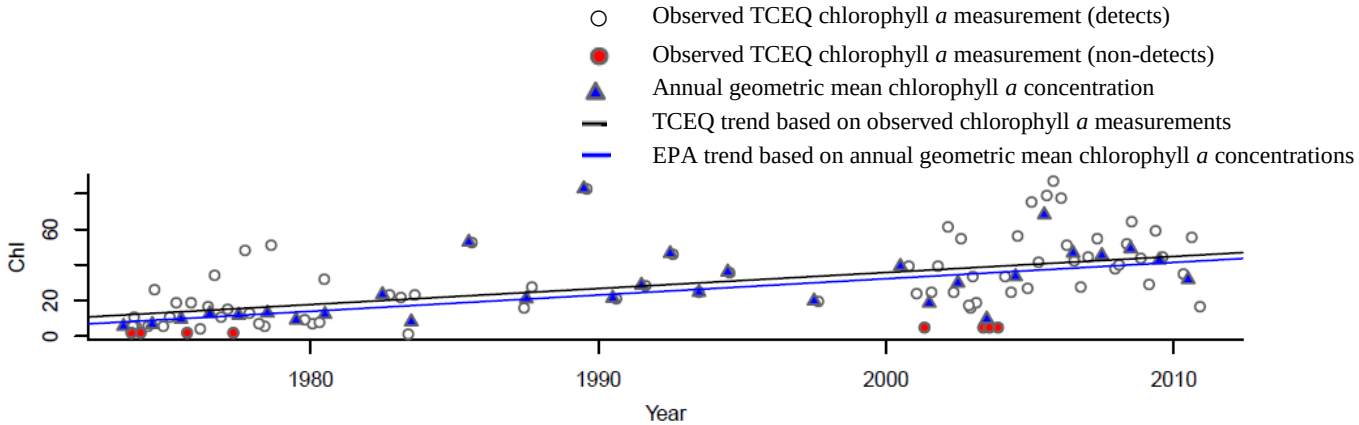
TCEQ Chlorophyll a Trend Analysis Results: In supporting documentation provided to EPA on October 7, 2011, TCEQ identified a statistically significant increasing trend using 82 chlorophyll *a* measurements collected from Murval Lake between 1973 and 2010 (see Figure 149). Because TCEQ noted that many of the monitoring entities in the state switched from the spectrophotometric to the fluorometric method for the analysis of chlorophyll *a* and that changes in minimum reporting limits over time may have created artificial trends in the chlorophyll *a* data, EPA further examined the dataset that TCEQ used to conduct the trends analysis for Murval Lake. Based upon the supporting information provided by TCEQ, a shift in methodology does appear to have occurred for this dataset in 2006 (with all data after 2006 being collected using the fluorometric method rather than the spectrophotometric method). Sixty-six chlorophyll *a* measurements were made using the spectrophotometric method, with 8 of these measurements (~12%) being reported as less than the minimum reporting limits. Sixteen measurements were made using the fluorometric method, with none of these measurements (0%) being reported as less than the minimum reporting limits. When TCEQ analyzed trends for each of these datasets separately, the chlorophyll *a* data collected using the fluorometic method did not show a statistically significant increasing trend, while the chlorophyll *a* data collected using the spectrophotometric method did show a statistically significant increasing trend. In further analyzing the spectrophotometric method dataset, EPA found that assigning values other than one-half the minimum reporting limit (for those values reported as being less than the minimum reporting limit) did not affect the statistical significance of this chlorophyll *a* trend to such a degree that the trend became statistically insignificant. Therefore, EPA believes that this increasing trend for Murval Lake is statistically significant.

Figure 149. Chlorophyll *a* Trend for Murval Lake Resulting from TCEQ Trend Analysis.



EPA Chlorophyll a Trend Analysis Results Using TCEQ Data: In addition to TCEQ's trend analysis described above, EPA modeled a trend for Murval Lake based on the annual geometric mean chlorophyll *a* concentrations calculated from the same dataset that TCEQ used to conduct its trend analysis (see Figure 150). Note that each annual geometric mean chlorophyll *a* concentration was weighted by the number of samples used to compute each average. For Murval Lake, the magnitude of the slope of this increasing trend was very high, relatively speaking, at 0.917 µg/L chlorophyll *a*/year.

Figure 150. Chlorophyll *a* Trends for Murval Lake Resulting from EPA Trend Analysis.



TCEQ Trophic State Classification Information: Murval Lake was included in TCEQ's report titled *Trophic Classification of Texas Reservoirs* which was developed in conjunction with the 2010 reporting cycle. EPA was able to use information provided in this report to characterize change in trophic state classification for Murval Lake between the 2000 and 2010 reporting cycles. According to the report, a Carlson's TSI value of 66.36 was determined for the 2010 reporting cycle for Murval Lake. This value

was based on an average of chlorophyll *a* TSI values calculated from 10 years of surface water quality monitoring data collected between December 1, 1998, and November 30, 2008, and was identified as being 1.55 points higher than the chlorophyll *a* TSI value for the 2000 reporting cycle (period of record was September 1, 1989 - August 31, 1999). According to the chlorophyll *a* TSI index range associated with each trophic class as identified in TCEQ's report, this indicates that Murval Lake was hypereutrophic for both the 2000 and 2010 reporting cycles.

Comparison of Reservoir-specific Chlorophyll a Criterion to Water Quality Management Thresholds Published in the Scientific Literature: For reasons described in more detail on page 5 of this Appendix and in the accompanying TSD, EPA evaluated the chlorophyll *a* criterion and the underlying chlorophyll *a* dataset provided by TCEQ for this reservoir against a chlorophyll *a* concentration threshold of 30 µg/L. For Murval Lake, the chlorophyll *a* criterion is above 30 µg/L and 39% of the chlorophyll *a* measurements in TCEQ's underlying chlorophyll *a* dataset were greater than 30 µg/L.

Overall Conclusion/EPA Action: Based on EPA's review of the reservoir-specific data and information available for Murval Lake, EPA concludes that TCEQ's critical underlying assumption (described on page 1 of this Appendix) is not satisfied in the case of Murval Lake. Reservoir-specific data and information described above indicates a hypereutrophic classification for Murval Lake, with a very high rate of chlorophyll *a* accumulation, relatively speaking, based on EPA's trend analysis (slope = 0.917 µg/L chlorophyll *a*/year) and a statistically significant increasing trend in chlorophyll *a* concentration based on EPA's review of TCEQ's trend analysis. TCEQ did not identify any CWA §303(d) listings for pH or DO for Murval Lake. TCEQ identified three concerns for chlorophyll *a* in Murval Lake in the 2006 through 2010 reporting cycles. And, though not considered repeating (as previously defined in Footnote 2), TCEQ identified one nutrient concern (OP) in the 2008 reporting cycle in Murval Lake. 2007 NLA data for Murval Lake indicated a high risk of exposure based on chlorophyll *a* and cyanobacteria thresholds and a low risk of exposure based on microcystin thresholds. Further, the chlorophyll *a* criterion for Murval Lake and 39% of the measurements in the underlying chlorophyll *a* dataset available for Murval Lake were greater than 30 µg/L. In drawing the conclusion that TCEQ's critical underlying assumption is not satisfied in the case of Murval Lake, EPA not only strongly considered the reservoir's hypereutrophic classification in the 2000 and 2010 reporting cycles, but also strongly considered the fact that the chlorophyll *a* criterion for Murval Lake and 39% of the measurements in the underlying chlorophyll *a* dataset available for Murval Lake were greater than 30 µg/L. With this being the case, EPA is concerned that the chlorophyll *a* criterion (which is derived and expressed as a long-term central tendency), is not likely to protect designated uses from the effects of high instantaneous chlorophyll *a* concentrations (such as nuisance blooms, toxic cyanobacteria and toxin production, taste and odor compound production, and disinfection byproduct production). Based on the above information, EPA concludes that the chlorophyll *a* criterion of 55.80 µg/L applicable to Murval Lake is not protective of the reservoir's designated uses as required by 40 CFR § 131.11(a)(1) and, therefore, EPA disapproves this reservoir-specific chlorophyll *a* criterion.