TENNESSEE'S PLAN FOR NUTRIENT CRITERIA DEVELOPMENT

Revised October, 2004

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I. INTRODUCTION

This plan describes the approach the Division of Water Pollution Control, Tennessee Department of Environment and Conservation, will use to identify and adopt additional water quality standards for nutrient related parameters that protect against measurable impacts to the aquatic environment. Tennessee has already made great strides in incorporating nutrient and biological criteria into its water quality standards. This plan is designed to build upon and refine the achievements already attained in the state.

Tennessee's plan for nutrient criteria development is in response to the U.S. EPA mandate requiring the adoption of nutrient criteria into state water quality standards by 2004. EPA has stated that since both the process for developing standards and the available resources may differ significantly between states, some may not have to adopt standards by 2004 as long as evaluations of progress show that criteria development is well underway and the state's efforts are consistent with its plan.

If U.S. EPA feels a state's plan is not appropriate or if a state has not adopted standards by 2004, the U.S. EPA administrator may exercise authority under section 303(c)(4)(B) of the Clean Water Act and find that promulgation of nutrient criteria for the state is necessary to meet the requirements of the Clean Water Act.

The push for nutrient criteria adoption is driven by state water quality inventories that repeatedly cite nutrients as a major cause of water quality use impairments. EPA's national water quality summary reports to Congress consistently identify excessive nutrients as one of the top three leading causes of impairments of the nation's water (along with siltation and pathogens). In Tennessee, nutrients are the fourth leading cause of use impairment in rivers and streams after siltation, habitat alteration, and pathogens (Figure 1). Nutrients are the third leading cause of pollution in reservoirs and lakes after PCBs and siltation.

Under section 303(d), States identify waters that are not attaining water quality standards and submit a list of those impaired waters to EPA. These lists also frequently identify excessive nutrients as a leading cause of impairment. In Tennessee, more than 1,500 stream miles have been identified as impaired due to nutrients. These nutrient-impaired stream segments are found in most of the state's major watersheds.

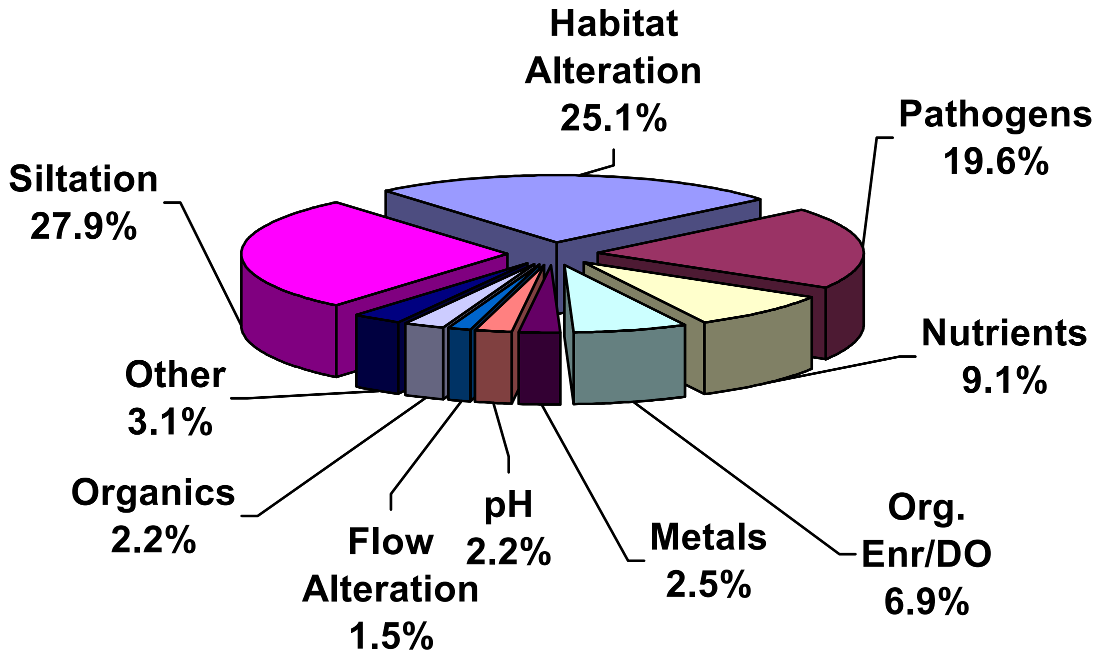


Figure 1: Relative Impacts of Pollution in Assessed Rivers and Streams in Tennessee (2002 305(b) Report)

Tennessee has made considerable progress developing nutrient targets for wadeable streams. However, less progress has been made for other waterbody types such as lakes, reservoirs, wetlands and large rivers. The purpose of this document is to identify methods that, resources permitting, could be used to identify nutrient goals for all the various waterbody types.

IMPORTANT NOTE:

This document is a plan that describes potential approaches for the refinement of existing nutrient criteria and the future development of specific criteria for additional waterbody types. Implementation of this plan will require either additional program resources or the diversion of resources from other program areas.

Nothing in this document should be taken to obligate the Division of Water Pollution Control to a course of action in the absence of program resources.

II. CRITERIA DEVELOPMENT OPTIONS

In 1998, EPA developed a National Nutrient Strategy for the development of a set of national criteria recommendations for nutrients for various waterbody types. The strategy was based on a statistical analysis of data aggregated from Level III ecoregions (Figure2). Tennessee has three of these nutrient regions: Region IX (Southeastern Temperate Forested Plains and Hills), Region X (Texas-Louisiana Coastal and Mississippi Alluvial Plains), and Region XI (Central and Eastern Forested Uplands). However, only a small portion of Tennessee's land area (Mississippi River delta) is in Region X.

As of 2004, EPA has published national nutrient criteria for streams and rivers, lakes, and wetlands. However, the criteria developed for wetlands are only applicable to a small portion of Florida (Region XIII). Additionally, even for streams and lakes, not all Level III ecoregions are covered.

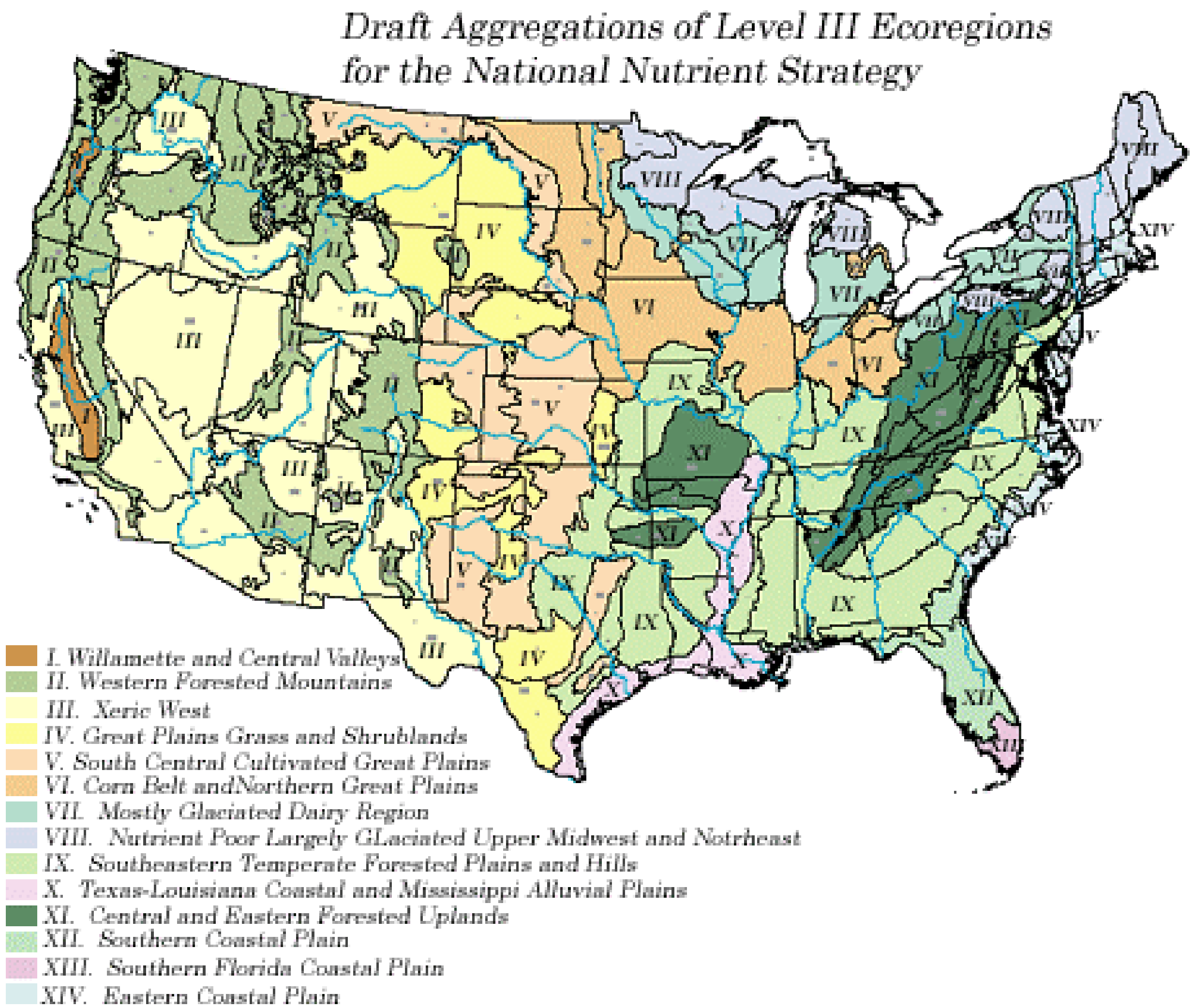


FIGURE 2. Level III Ecoregions of the United States.
(Source: EPA Office of Water Web Page.)

It should be noted that Dr. Sherry Wang and Greg Denton of the Tennessee Division of Water Pollution Control participated in the development of the national nutrient criteria for rivers and streams as members of the national criteria development team. A case study from Tennessee appeared in the rivers and streams criteria document. Additionally, Mr. Denton and Dr. Wang serve on the nutrient criteria Regional Technical Advisory Group (RTAG) for Region IV.

The table below summarizes the EPA national nutrient criteria recommendations for the three Level III nutrient regions in Tennessee for rivers and streams (Table 1), plus two regions for lakes and reservoirs (Table 2). As stated previously, there are no national nutrient criteria for wetlands in any of the three Level III ecoregions in Tennessee. The source of these data was EPA's nutrient criteria webpage, Summary Table for Nutrient Criteria Documents, which can be accessed at (http://www.epa.gov/waterscience/criteria/nutrient/ecoregions/).

Table 1. Aggregate Ecoregions for Rivers and Streams

PARAMETER	ECOREGION IX	ECOREGION X	ECOREGION XI
Total Phosphorus (ug/L)	36.56	128.00*	10.00
Total Nitrogen (mg/L)	0.69	0.76	0.31
Chlorophyll *a* (ug/L)	0.93	2.10	1.61
Turbidity (FTU/NTU)	5.70	17.50	2.30

* EPA believes that this value may be a statistical anomaly and recommends further evaluation.

Table 2. Aggregate Ecoregions for Lakes and Reservoirs

PARAMETER	ECOREGION IX	ECOREGION X	ECOREGION XI
Total Phosphorus (ug/L)	20.00	Under development	8.00
Total Nitrogen (mg/L)	0.36	Under development	0.46
Chlorophyll *a* (ug/L)	4.93	Under development	2.79
Secchi Depth (meters)	1.53	Under development	2.86

If EPA were required to promulgate nutrient criteria for individual states, the criteria would be based on EPA's published national recommendations. However, EPA has stated clearly that federal promulgation is not their preferred approach and instead, recommends that where ever possible, the states should develop nutrient criteria that fully reflect localized conditions and protect specific designated uses. This is also Tennessee's preferred approach.

EPA has also stated a willingness to provide states with some flexibility concerning the parameters or constituents that provide the basis for criteria development. Causative factors are the pollutants such as nitrogen or phosphorus that stimulate excessive biomass. Response factors are measurements of the effects of the excess nutrients, such as elevated chlorophyll *a* levels or reduced secchi depths. While EPA has recommended that states base criteria on both causative and response factors, many state appear to have a preference for one or the other. EPA has acknowledged that approaches that emphasize one set of factors over another can be acceptable.

III. TENNESSEE'S NUTRIENT CRITERIA DEVELOPMENT ACTIVITIES PRIOR TO 2004

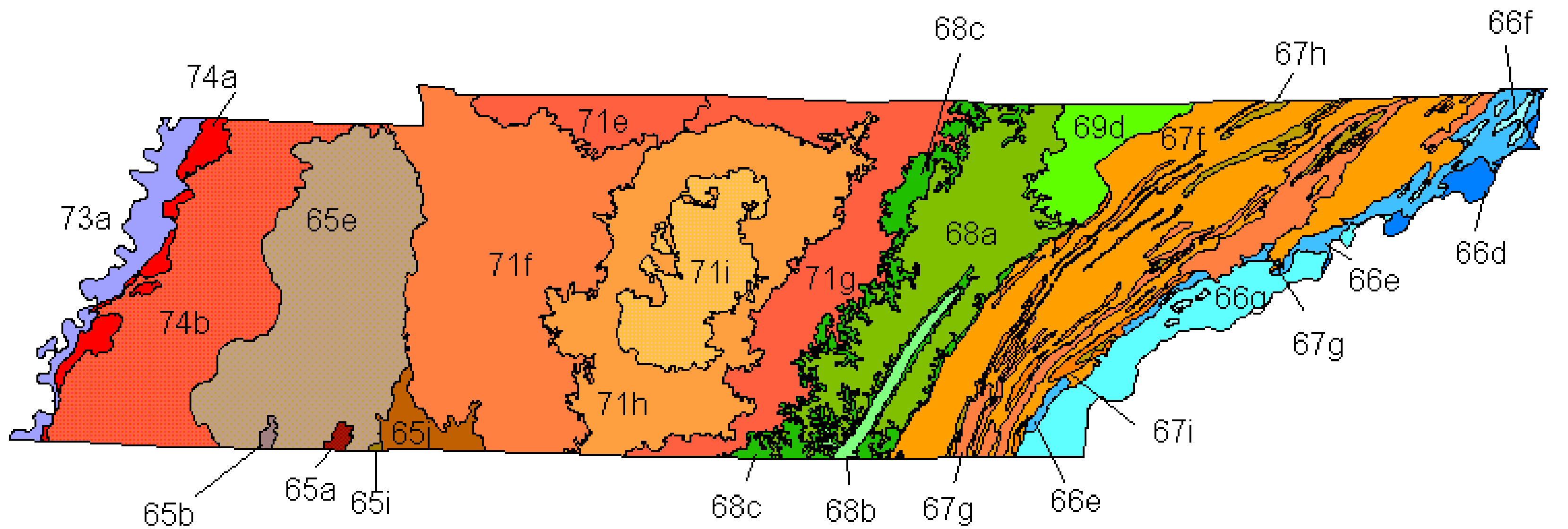
For wadeable streams, Tennessee has selected an approach to criteria development that blends recommendations from EPA with our own primary research into nutrient levels in the various parts of the state. In fact, when the national nutrient strategy document was developed in 1998, Tennessee was already several years into a project studying water quality at carefully selected reference streams.

The Tennessee Ecoregion Project began in 1993 when Tennessee, with the help of 104(b)(3) funds, arranged for James Omernik and Glen Griffith from the EPA National Health and Environmental Research Laboratory to subregionalize and update the national Level III ecoregions that were developed in 1986.

During the delineation process, maps containing information on bedrock and surface geology, soil, hydrology, physiography, topography, precipitation, land use and vegetation were reviewed. Interagency cooperation widened the base of maps, information and resources available to delineate subregions. Much of this information was digitized to produce draft maps of ecoregion and subregion boundaries.

Multiple agencies were invited and represented at three ecoregion meetings held during 1994-95. Attendees included aquatic biologists, ecologists, foresters, chemists, geographers, engineers, university professors and regulatory personnel from 37 state and federal agencies as well as universities and private organizations. The judgment of these experts was applied throughout the selection, analysis and classification of data to determine the final ecoregion and subregion boundaries in Tennessee (Griffith, 1997).

Ecoregion delineation culminated in 1997 with the publication of a map outlining 25 Level IV ecoregions (Figure 3).



65a Blackland Prairie	67f Southern Limestone/Dolomite Valleys and Low Rolling Hills	71e Western Pennyroyal Karst
65b Flatwoods/Alluvial Prairie Margins	67g Southern Shale Valleys	71f Western Highland Rim
65e Southeastern Plains and Hills	67h Southern Sandstone Ridges	71g Eastern Highland Rim
65i Fall Line Hills	67i Southern Dissected Ridges & Knobs	71h Outer Nashville Basin
65j Transition Hills	68a Cumberland Plateau	71i Inner Nashville Basin
66d Southern Igneous Ridges & Mtns	68b Sequatchie Valley	73a Northern Mississippi Alluvial Plain
66e Southern Sedimentary Ridges	68c Plateau Escarpment	74a Bluff Hills
66f Limestone Valleys and Coves	69d Cumberland Mountains	74b Loess Plains
66g Southern Metasedimentary Mtns.		

Figure 3: Level IV Ecoregions of Tennessee

In parallel with the delineation efforts, in 1994, work began to identify reference streams throughout the state. Reference streams were least impacted, but representative, waterbodies in each of the subecoregions. Candidate reference streams were selected based on landuse and the general absence of land-disturbing activities. Candidate streams were initially surveyed and approximately 100 of the best were selected for intensive monitoring.

Except for some of the very small subecorogions, we were able to establish a minimum of five reference streams in each area.

For the next three years, the division intensively monitored each reference stream for physical, biological, and chemical characteristics. Total phosphorus and nitrate+nitrite data were included in these analyses, however, total nitrogen was not. Reference sites have continued to be sampled since then, but in conjunction with the watershed cycle, rather than intensively as before.

In 2001, the division published a document entitled, *Development of Regionally-based Interpretations of Tennessee's Narrative Nutrient Criterion*. The report:

1. Documented the 75th and 90th percentiles of the total phosphorus and nitrate+nitrite data from each subecoregion.

2. Identified adjoining Level IV subregions that could be combined due to the lack of a statistically significant difference in the data from each.

3. Tested both the 75th and 90th percentiles with the benthic community survey results at test sites to see how well each potential criteria level predicted biological impairment.

4. Proposed the 90th percentile as the basis for clean water goal setting.

5. Established an implementation procedure for application of the narrative criteria.

In 2002, the division formally proposed to the Water Quality Control Board that the total phosphorus and nitrate+nitrite targets based on the 90th percentile established in the 2001 nutrient document be promulgated as water quality criteria. Additionally, the division suggested that a narrative nutrient criterion for protection of the recreational use be adopted. The following language was suggested:

The waters shall not contain nutrients in concentrations that stimulate aquatic plant life and/or algae growth to the extent that the public's recreational uses of the stream or other downstream waters are detrimentally effected.

The set of revisions was drafted and rulemaking procedures were initiated.

In the spring of 2003, a court case challenged the division's ability to identify nutrient-impaired waters and to set permit limitations for nutrients, due to the lack of a water quality criterion specific to that condition. In response, the Board approved an emergency rule for nutrients. The emergency rule, which was narrative in nature, stated:

> *(m) The waters shall not contain nutrients in concentrations that stimulate aquatic plant and/or algae growth to the extent that aquatic habitat is substantially reduced and /or the biological integrity fails to meet regional goals. Additionally, the quality of downstream waters shall not be detrimentally affected.*
>
> *Interpretation of this provision may be made using the document Development of Regionally-based Interpretations of Tennessee's Narrative Nutrient Criterion and/or other scientifically defensible methods.*

The wording of the emergency rule did several significant things. First, as part of the criteria for protection of fish and aquatic life, it applied to all waters, since all waters in Tennessee have that designated use assigned to them. Since the criterion was non-specific, it applied to all waterbody types and established the importance of physical (habitat) and biological data in interpreting the criterion. Additionally, for wadeable streams, it established the division's procedure based on reference stream data, as the preferred method of interpretation.

This emergency rule, once promulgated, was then approved by EPA in December, 2003.

In August, 2003, EPA raised concerns about the promulgation of numeric criteria based on the 90th percentile of the reference stream data. Additionally, the public and the regulated community did not appear to support numeric criteria. In response, the division removed the proposed numeric criteria and substituted the narrative criterion language from the emergency rule.

All the proposed revisions to water quality standards were promulgated by the Board in September, 2003. Following certification by the Attorney General's office, the rulemaking hearing rules were transmitted to EPA. The state rulemaking process was completed in January, 2004. In September 2004, EPA formally approved almost all of Tennessee's revisions, including the narrative nutrient criterion. (As stated previously, EPA had already approved the same language in the emergency nutrient criterion.)

There are several reasons that Tennessee chose not to use EPA's national nutrient criteria recommendations for wadeable streams. The first and most obvious is that EPA stated a preference that states develop their own regionally-based nutrient criteria. The national database used by EPA included data from large rivers and streams that cross Level IV ecoregion boundaries. Tennessee's reference database was restricted to streams that had at least 80% of the upstream drainage included within the targeted subregions.

Another source of concern about EPA's national nutrient criteria recommendations is that a statistical approach was used to derive the national criteria without consideration of cause-effect relationships. Tennessee has utilized an approach that incorporates not only the identification of the reference condition, but also considers the effects of nutrient enrichment to the biological community. We consider this approach a more appropriate method of determining nutrient thresholds for the protection of designated uses.

A Level IV or ecological subregion approach is much more refined and indicative of local conditions. Subregions in Tennessee were often statistically different from other subregions in the same Level III ecoregion. Basing criteria on Level III data is not sensitive to obvious regional differences.

Regarding other waterbody types such as lakes and reservoirs, we are not certain that an ecoregional framework will be as helpful as it was with rivers and streams. We are aware that Florida used such an approach for their lakes, however, most of their lakes are of natural origin, while most of Tennessee's are impoundments. The characteristic of reservoirs seem to us to be more controlled by the size and type of dam, the contours of the flooded valley, retentions times, and inflow and outflow rates.

IV. CLASSIFICATION BY WATERBODY TYPE

As previously stated, all waterbody types in Tennessee are currently covered by the EPA-approved narrative nutrient criterion. Under his rule, a methodology for interpreting the criterion in wadeable streams is specified. In order to continue development of more specific nutrient criteria, we need to identify groupings for the various waterbody types. Classification refers to the way waterbodies can be grouped for criteria development.

Tennessee plans to classify waterbodies in the following manner:

Streams and Rivers

<u>Wadeable Streams</u>

For nutrient criteria purposes, these waters have also been grouped by nutrient regions (total phosphorus and nitrate+nitrite) based on statistical similarity between reference data in the Level IV ecological subregions (Figures 4 and 5). From the 25 Level IV subregions in Tennessee, nutrient regions have been grouped into 15 nitrate+nitrite and 15 total phosphorus. Although both groups have 15 regions, they do not exactly overlap.

Reference conditions have not yet been established for wadeable streams that cross more than one nutrient region.

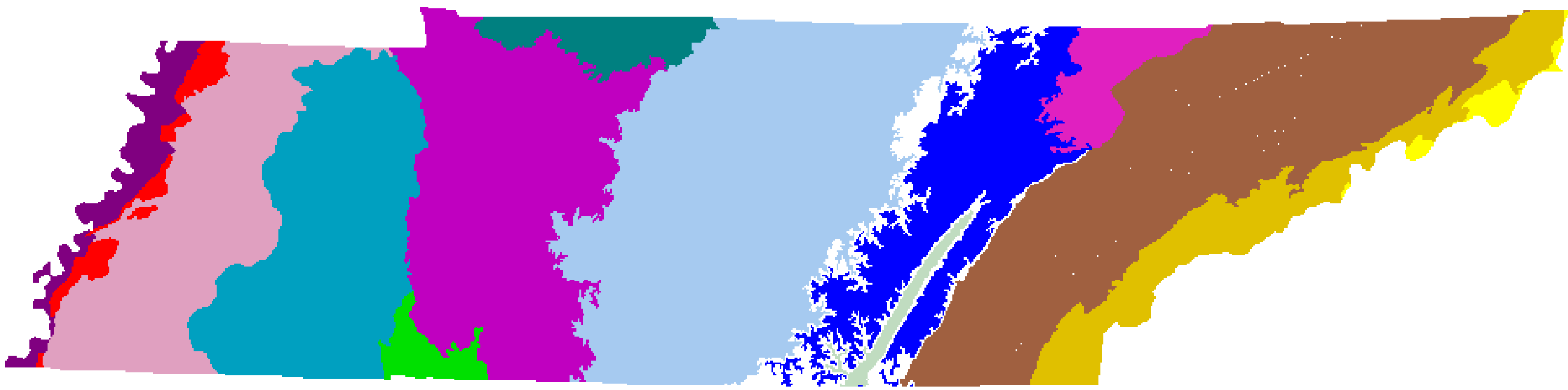


Figure 4: Nitrate+Nitrite Regions for Wadeable Streams in Tennessee

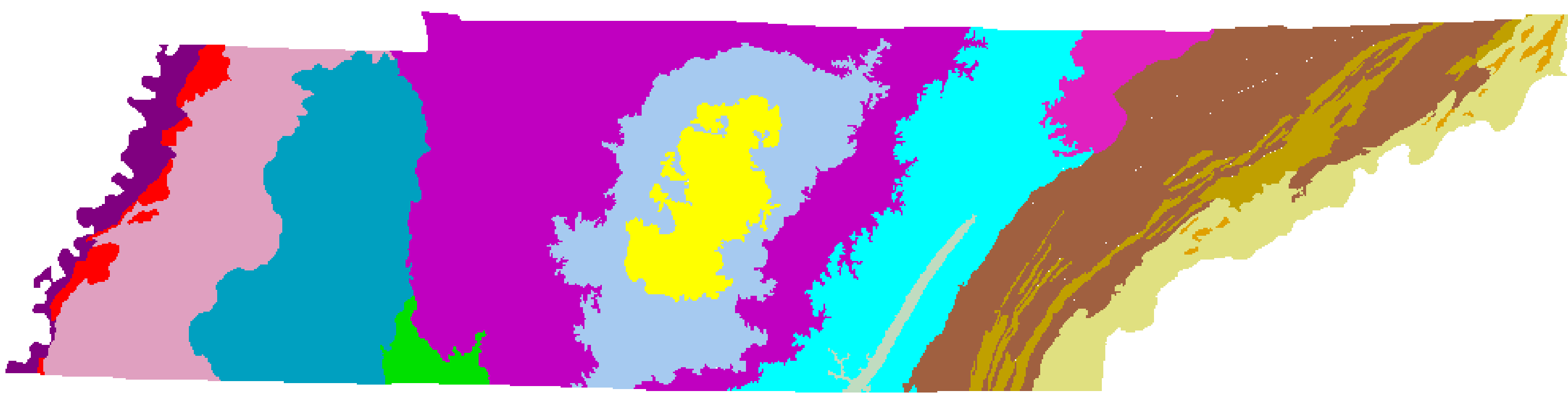


Figure 5: Total Phosphorus Regions for Wadeable Streams in Tennessee

Non-wadeable streams and rivers

Reference conditions have been established for non-wadeable waters in nutrient regions 74b and 73a (for both nitrate+nitrite and total phosphorus). Reference streams have not been established for non-wadeable flowing water in other regions or for those waters that cross multiple subregions. Preliminary sites have been targeted and will be monitored as part of a 104(b)(3) grant in summer 2004 for rivers and large streams crossing ecoregions 65e and 74b in west Tennessee.

Lakes and Reservoirs

Tennessee will initiate development of specific nutrient guidelines for lakes and reservoirs beginning with a review of existing data. For the initial review of data, lentic systems will be divided into the following broad categories. It is possible they will be further divided into sub-categories. It is too early to determine whether the ecoregion concept will be applicable to lakes and reservoirs or whether some other classification approach needs to be developed.

As stated earlier, we have reservations that the ecoregion approach will be useful in the case of man-made impoundments.

Natural Lakes

Many of Tennessee's significant natural lakes are in West Tennessee, especially along the Mississippi River. (It is often, but not correctly, said that Reelfoot Lake is Tennessee's only natural lake. While Reelfoot is undoubtedly the largest natural lake in Tennessee, a cursory review of West Tennessee topo maps will reveal many other lakes of natural origin in Tennessee.)

While it might be possible to have an ecoregional basis for natural lakes, the problem in West Tennessee would be that the significant amount of agricultural land conversion and extensive hydrological modification (leveeing and channelization of tributaries) would make it difficult to find suitable reference sites in Tennessee. However, suitable sites might be found either in Tennessee or neighboring states.

Extensive water quality investigations were conducted at Reelfoot Lake in the 1980s (TDHE, 1984 and Denton, 1987). This lake is already listed as nutrient impaired due to elevated chlorophyll *a* levels and nuisance aquatic plants. The dense stands of aquatic plants interfere with recreational boating.

Large Reservoirs (> 1000 acres)

Tennessee has 30 large reservoirs over one thousand acres. They range in size from the 1,749 acre Chilhowee Reservoir on the Little Tennessee River to the 99,500 acre Kentucky Lake on the Tennessee River. Most of these reservoirs are managed by the Tennessee Valley Authority (TVA) or the U.S. Army Corps of Engineers (USACE). Six are shared with other states including Kentucky Lake, Lake Barkley and Dale Hollow (Kentucky); South Holston Lake (Virginia); Guntersville Lake (Alabama); and Pickwick Lake (Alabama and Mississippi). Expertise and data are available from all these sources and will be useful as part of the criteria development process.

Medium Reservoirs (200 – 1000 acres)

Tennessee has 56 reservoirs falling in this category. This includes those managed by TVA, TWRA (Tennessee Wildlife Resources Agency), municipalities, state parks and private developers. With the exception of the TVA managed reservoirs, water quality data are generally scarce at these reservoirs. Some historic data are available for the state park impoundments.

A factor to consider is that the TWRA impoundments are fertilized to promote fish production. While the Division of Water Pollution Control has strong reservations about this practice, it may be that criteria in these fishing reservoirs need to focus more on the protection of downstream reaches, rather than prevention of over enrichment in the reservoir water column.

Small Reservoirs (< 200 acres)

Tennessee has 1,161 reservoirs under 200 acres. These include one TVA managed reservoir (Wilbur Lake), municipal lakes, state parks, city parks, resorts, community developments, farm ponds and private lakes. There is little historic data on many of these impoundments. Although they are small, they are often in headwater areas and have the potential to affect downstream reaches. As part of a 104(b)(3) probabilistic study, Tennessee is currently monitoring the downstream areas of 75 small and medium reservoirs. This information will be used in the nutrient criteria development process for small reservoirs.

Wetlands

Tennessee has approximately 787,000 acres of wetlands. The Division has identified 54,811 impacted wetland acres. The largest single cause of impact to existing wetlands is loss of hydrologic function due to channelization and leveeing.

Wetlands are currently covered under the general narrative nutrient criteria. Tennessee does not currently have the resources or data available for development of wetland specific nutrient criteria. Protection and restoration of wetlands from physical alterations has historically been considered a higher priority.

Tennessee was one of the first states in the nation to have a wetlands protection strategy and has been recognized by EPA as establishing a national model for wetlands planning. Wetland nutrient criteria will be considered after nutrient criteria for flowing waters and reservoirs are established and after more guidance is provided by U.S. EPA.

V. CRITERIA DEVELOPMENT APPROACH BY WATERBODY TYPE

The focus of Tennessee's nutrient criteria strategy is based primarily on the linkage between nutrient concentrations and impairment of designated uses. Both causative variables such as phosphorus and nitrate+nitrite as well as response variables such as the health of the macroinvertebrate community are taken into consideration. The establishment of nutrient criteria has been and will continue to be founded on the results of comprehensive cause and effect-based study and analysis.

Wadeable Streams

Tennessee has been researching nutrient levels in wadeable streams since 1995 and has used these data to develop nutrient criteria as outlined in the document *Development of Regionally-Based Interpretations of Tennessee's Narrative Nutrient* Criterion, (Denton et al, 2001). This document is referenced as a translator (along with other scientifically defensible data) in Tennessee's narrative nutrient criterion, which became a state rule in January 2004. The nutrient criterion is tied-in with the biological criteria for an effects-based approach.

The guidelines are based on data collected primarily from 1996 to 1999, consisting of chemical, physical and biological samples collected in least-impacted, yet representative, streams in 25 Level IV ecological subregions across the state. Data continues to be collected from these streams on the five-year watershed cycle. Several studies have been conducted to develop and refine the regionalized nutrient criteria guidelines.

<u>Ecoregion Reference Stream Study</u>

Three hundred and fifty-three potential reference sites were evaluated as part of the ecoregion project. The reference sites were chosen to represent the best attainable conditions for all streams with similar characteristics in a given subregion. Reference conditions represented a set of expectations for physical habitat, general water quality and the health of the biological communities in the absence of human disturbance and pollution.

Selection criteria for reference sites included minimal impairment and representativeness. Streams that did not flow across subregions were targeted so the distinctive characteristics of each subregion could be identified.

Based on EPA recommendations, three reference streams per subregion were considered the minimum necessary for statistical validity. Only two streams could be found in some smaller subregions. Seventy streams were targeted for intensive monitoring beginning in 1996.

After analysis of the first year's data, it was determined that a minimum of five streams per subregion would be more appropriate. Where possible, additional reference streams were added. However, in smaller subregions or those with widespread human impact this was not possible. Forty-four reference streams were added to the study resulting in intensive monitoring at 114 sites beginning in fall 1997. There were between two and eight reference streams targeted in each subregion.

All reference sites were monitored quarterly for three consecutive years. Since 1999, sites have been monitored quarterly as part of the five year watershed cycle. New reference sites are added as they are located during watershed or probabilistic monitoring. Conversely, some of those originally selected have been dropped due to increased disturbances or unsuitability. There are currently 99 active reference sites.

During the nutrient criteria development process, the data were analyzed for relationships between other parameters and nutrient levels at reference streams. Relationships were investigated primarily for turbidity, total organic carbon (TOC) and total suspended solids. Somewhat weak relationships between total organic carbon and turbidity were documented with total phosphorus levels. This study is documented in the USEPA report (EPA-822-B-00-002, Appendix A). These relationships will continue to be analyzed as more data become available.

Nutrient concentrations were compared between each subregion to determine groupings for nutrient regions. Fisher's Protected Least Significant Difference at significance level of 5% was used to determine which subregions could be combined. Reference data from the Alabama Department of Environmental Management was used to support pooling of small subregions in the Southeastern Plains (65).

Tennessee's regional nutrient guidelines were set at the 90th percentile of reference data for each region. Since Tennessee is using causal responses based on macroinvertebrate communities to define nutrient criteria violations, both the 90th and 75th percentile of reference data were evaluated for criteria development. Relationships between biological stream health and nutrient concentrations were explored using reference stream data, probabilistic data, and data from targeted monitoring.

Based on a comparison to biocriteria guidelines throughout the state, the 75th percentile often targeted streams as nutrient enriched that showed no biological impairment (Table 3 and Figure 6). On the other hand, streams that exceeded the 90th percentile generally had biological impairment. Therefore, regional nutrient criteria were proposed for both NO2+NO3 and total phosphorus at the 90th percentile of reference data.

Table 3: Comparison of 75th and 90th percentiles of nutrient data to biological impairment at 99 test sites in 4 Level IV ecoregions.

Region(s)	Sample description	Number of sites that exceed 75th percentile NO2+3 or TP	Number of sites that exceed 90th percentile NO2+3 or TP	Number of sites that fail biocriteria guidelines (cause not necessarily nutrients)
Inner Nashville Basin (71i)	Probabilistic monitoring at 50 sites (3x macroinvertebrates, 5x nutrients)	39	19	32
Southern Limestone/Dolomite Valleys and Low Rolling Hills (67f)	38 sites 1996-2001	30	14	15
Loess Plains (74b)	23 sites with a minimum of 6 nutrient samples 1996-1999	20	14	18
Southeastern Plains and Hills (65e)	12 sites	10	7	9

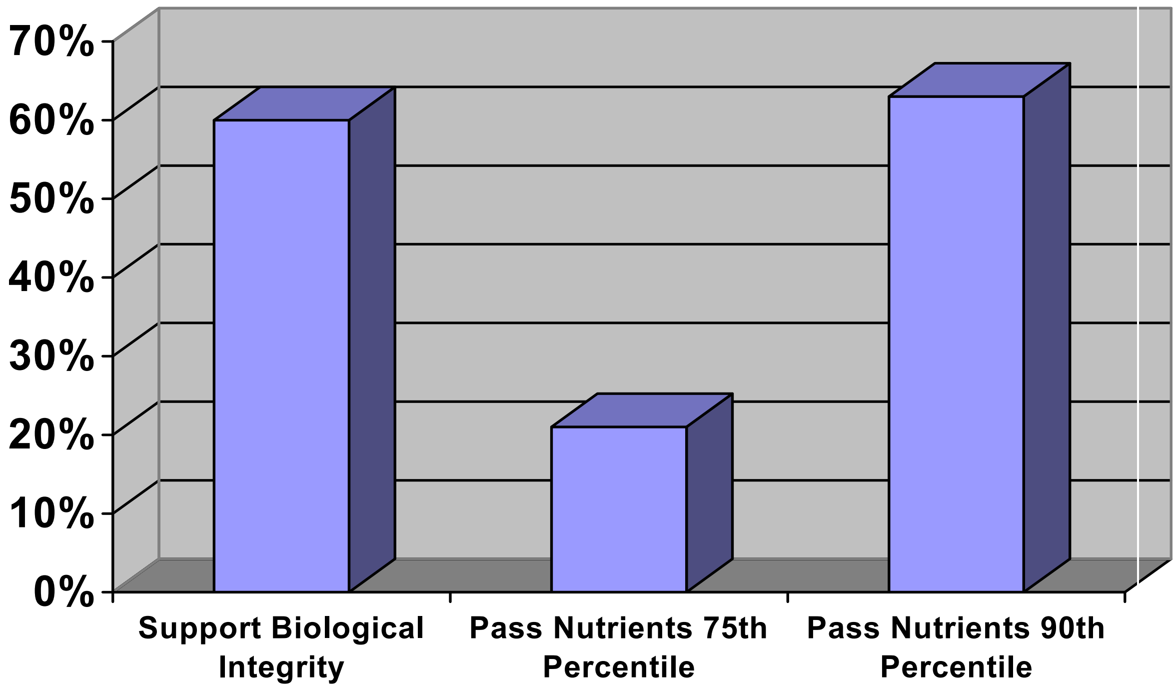


Figure 6: Comparison of Sites Supporting Biological Integrity With Proposed Nutrient Criteria at 75th and 90th Percentiles

At the time the guidelines was published in 2001, 916 data points from reference streams were used to calculate regional criteria guidelines for total phosphorus and nitrate+nitrate at the 90th percentile. Values are checked annually using additional data collected from reference sites through the year.

In 2004, 1,315 data points were available. Very little change has been observed in most regions with the additional data although total phosphorus data from the Interior Plateau may warrant regrouping subregions for total phosphorus (Tables 4 and 5).

Tennessee intends to continue to investigate nutrient levels at reference and test sites. However, we are satisfied that guidelines set at the 90th percentile using regional reference data are appropriate and can be justified. The ten years of research and nine years of data collection used to establish these regional guidelines indicate that the 90th percentile is a more predictor of biological impairment in Tennessee ecoregions than the EPA's guidelines based on the 75th percentile of aggregated Levels III data.

Table 4: 90th percentile of reference total phosphorus data by ecological subregion (Data in mg/L)

August 2001 N = 916			January 2004 N = 1315		
Grouped Subregions	90th percentile	Count	Grouped Subregions	90th Percentile	Count
73a	0.25	19	73a	0.26	30
74a	0.12	28	74a	0.17	42
74b	0.10	42	74b	0.14	70
65a, 65b, 65e, 65i	0.04	74	65a, 65b, 65e, 65i	0.04	104
65j	0.04	53	65j	0.04	71
71e	0.04	38	71e, 71f, 71g	0.04	212
71f, 71g	0.03	112			
71h, 71i	0.18	105	71h	0.09	72
71i			71i	0.21	105
68a, 68c	0.02	101	68a, 68c	0.02	148
68b	0.04	31	68b	0.08	42
69d	0.02	50	69d	0.02	65
67f, 67h, 67i	0.04	72	67f, 67h, 67i	0.03	97
67g	0.09	25	67g	0.11	43
66d, 66e, 66g	0.01	114	66d, 66e, 66g	0.02	175
66f	0.02	22	66f	0.03	39

The use of regional reference data follows EPA's recommendation that states establish localized guidelines when possible. The use of the 90th percentile meets Tennessee's desire to base nutrient guidelines on a cause and effect relationship rather than a purely statistical approach and is consistent with both Tennessee's and EPA's goals to protect designated uses. Past concerns EPA has expressed with Tennessee's approach have been considered and are addressed in Appendix A.

Tennessee is performing many studies relating to nutrient enrichment as described in the next section. These studies are expected to enhance the understanding of the effects of nutrient enrichment on streams. However, Tennessee feels that the regional nutrient guidelines at the 90th percentile in conjunction with documentation of macroinvertebrate assemblages is an effective way to assess nutrient impairment and intends to go forward with this as the primary approach.

Table 5: 90th percentile of reference nitrate+nitrite data by ecological subregion (Data in mg/L)

August 2001 N = 885			January 2004 N = 1353		
Grouped Subregions	90th percentile	Count	Grouped Subregions	90th percentile	Count
73a	0.39	19	73a	0.33	31
74a	0.22	27	74a	0.21	41
74b	1.19	42	74b	1.20	70
65a, 65b, 65e, 65i	0.34	74	65a, 65b, 65e, 65i, 65j	0.28	176
65j	0.22	53			
71e	3.48	37	71e	3.44	41
71f	0.38	69	71f	0.39	113
71g, 71h, 71i	0.94	148	71g, 71h, 71i	0.88	233
68a	0.23	73	68a	0.23	100
68b	0.45	31	68b, 68c	0.40	89
68c	0.31	28			
69d	0.27	50	69d	0.27	63
67f, 67g, 67h, 67i	1.22	97	67f, 67g, 67h, 67i	1.24	181
66d	0.50	32	66d, 66e, 66f, 66g	0.31	215
66e, 66f, 66g	0.31	105			

Probabilistic Monitoring Study

In 2001, 104(b)(3) grant monies were awarded to extend a probabilistic study of water quality in the Inner Nashville Basin (ecoregion 71i). The focus of this phase of the study was to explore the relationship between nutrient levels and the biological community (Arnwine et. al., 2003). The metric with the strongest response to total phosphorus was EPT richness (Figure 7). The percent chironomids and oligochaetes (%OC) was the biometric most affected by nitrate+nitrite concentrations (Figure 8).

The relationships between nutrients and macroinvertebrate biometrics were strengthened when percent canopy was included as a variable (Tables 6 and 7). Data show the absence of canopy played a significant role in the response of macroinvertebrates to elevated nutrient levels.

This study has resulted in percent canopy measures routinely being added to biological surveys. When possible, periphyton abundance is also measured, especially if nutrients are a concern. Due to manpower, expertise and funding constraints, it is unlikely Tennessee will include periphyton surveys requiring taxonomic identification as a regular survey activity although it may be included in special projects.

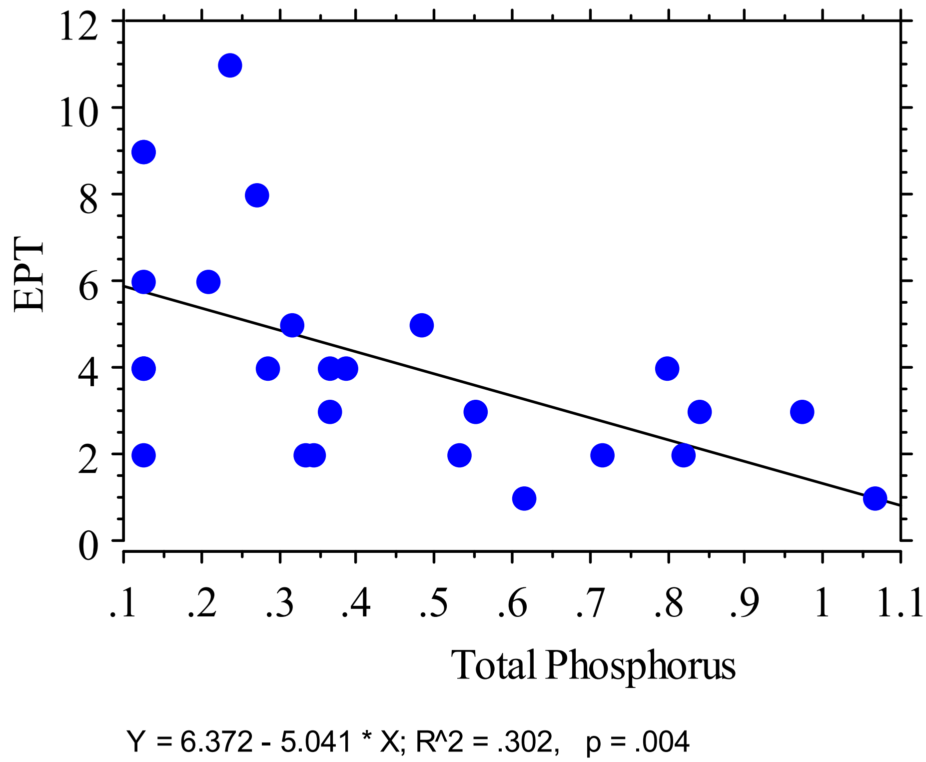


Figure 7: Relationship between total phosphorus levels and EPT taxa richness during low flow conditions. Data represents 21 probabilistic monitoring sites and two ecoregion reference sites in the Inner Nashville Basin.

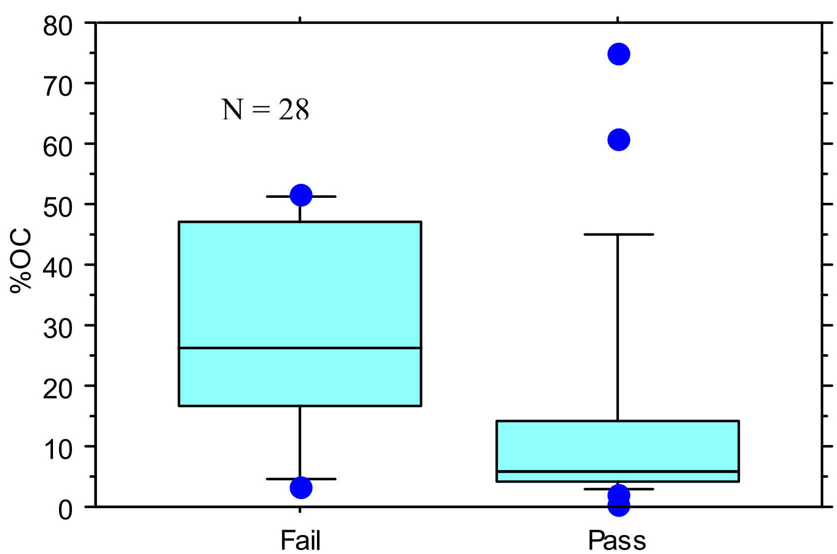


Figure 8: Distribution of Oligochaeta and Chironomidae abundance at sites with nitrate+nitrite levels above (fail) and below (pass) regional guidelines. Data represent 21 probabilistic sites and two ecoregion reference sites collected in fall 2000 in the Inner Nashville Basin.

Table 6: Relationship (adjusted R^2) between nutrient levels and nine biometrics at 50 test sites and two reference sites. Values in bold $p < 0.05$.

	Fall			Spring		
Biometric	**NO2-3**	**TP**	**NO2-3 TP**	**NO2-3**	**TP**	**NO2-3 TP**
Count	26	26	26	101	101	101
TMI	-.001	-.086	.010	-.001	+.025	.005
TR	+.049	-.014	..057	-.006	+.012	.016
EPT	+.071	**-.302**	**.283**	-.002	+.004	.005
%EPT	**-.149**	-.016	.110	+.004	+.00003	.004
%OC	**+.190**	+.004	.137	+.003	+.025	.011
NCBI	-.042	+.117	.067	-.020	-.011	.015
%DOM	-.005	+.002	.006	+.001	-.036	.016
%CLING	+.009	-.133	.060	-.002	-.091	.073
%NUTOL	**+.221**	+.009	**.186**	-.003	+.013	.015

Table 7: Relationships (adjusted R^2) between nutrient levels, canopy cover and nine biometrics. Samples collected at 50 probabilistic monitoring sites and two reference sites. Values in bold are statistically significant ($p < 0.05$)

	Fall				Spring			
Bio-metric	**Canopy**	**Canopy NO2-3**	**Canopy TP**	**Canopy NO2-3 TP**	**Canopy**	**Canopy NO2-3**	**Canopy TP**	**Canopy NO2-3 TP**
Count	16	16	16	16	92	90	90	90
TMI	**+.243**	.161	**.566**	**.549**	+.007	.007	.013	.002
TR	+.080	.082	.084	.017	+.012	.001	.031	.023
EPT	+.053	.058	**.280**	.237	-.022	.017	.002	.025
%EPT	+.039	.143	.078	.103	-.021	.002	.018	.026
%OC	+.027	**.567**	.131	**.615**	**-.046**	.036	**.057**	**.064**
NCBI	-.180	.054	**.417**	**.373**	**+.087**	**.108**	.089	**.108**
%DOM	-.030	.033	.125	.126	+.001	.002	.028	.019
%CLING	+.221	.133	**.641**	**.626**	-.018	.006	**.055**	.078
%NUTOL	+.001	.018	.082	.062	-.016	.015	.016	.017

Periphyton Study

In 2002, Tennessee was awarded federal nutrient criteria development funds to conduct algal density field surveys and nutrient sampling for comparison to diurnal dissolved oxygen patterns of 78 reference and impaired streams in 15 ecological subregions (Arnwine and Sparks, 2003).

Based on this preliminary study, periphyton densities were not always a good predictor of nutrient levels. At many test sites, nutrients were elevated, but periphyton abundance was similar to reference levels. Many streams, especially small ones, have canopies that block sunlight and keep water temperatures down which inhibits algal growth. In addition, the abundance of grazing animals such as snails would have an impact on algal density.

Dissolved oxygen levels appeared to be affected by the amount of periphyton present in the streams. Although levels generally stayed above regional criteria, diurnal fluctuations were more pronounced when algal densities were above reference stream conditions (Figures 9 and 10). Previous studies have indicated that extreme changes in dissolved oxygen levels can have a detrimental affect on aquatic life even when criteria for minimum concentrations are met. The type of periphyton (macroalgae or microalgae) did not appear to be as strong an influence on dissolved oxygen fluctuations as the abundance.

This study demonstrated the value of collecting and comparing canopy measurements and macroinvertebrate data (grazer abundance) when conducting periphyton surveys.

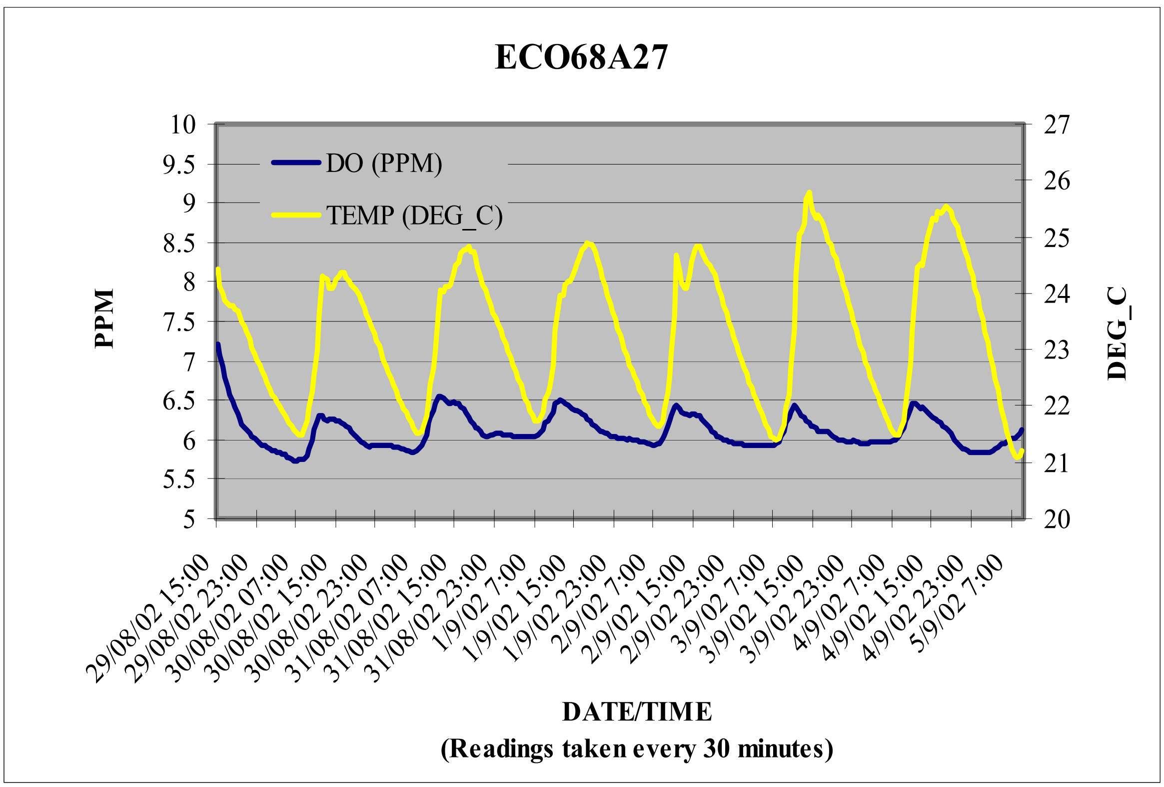


Figure 9: Diurnal dissolved oxygen and temperature data, Island Creek reference site, Cumberland Plateau (68a). Readings every 30 minutes for 162 hours.

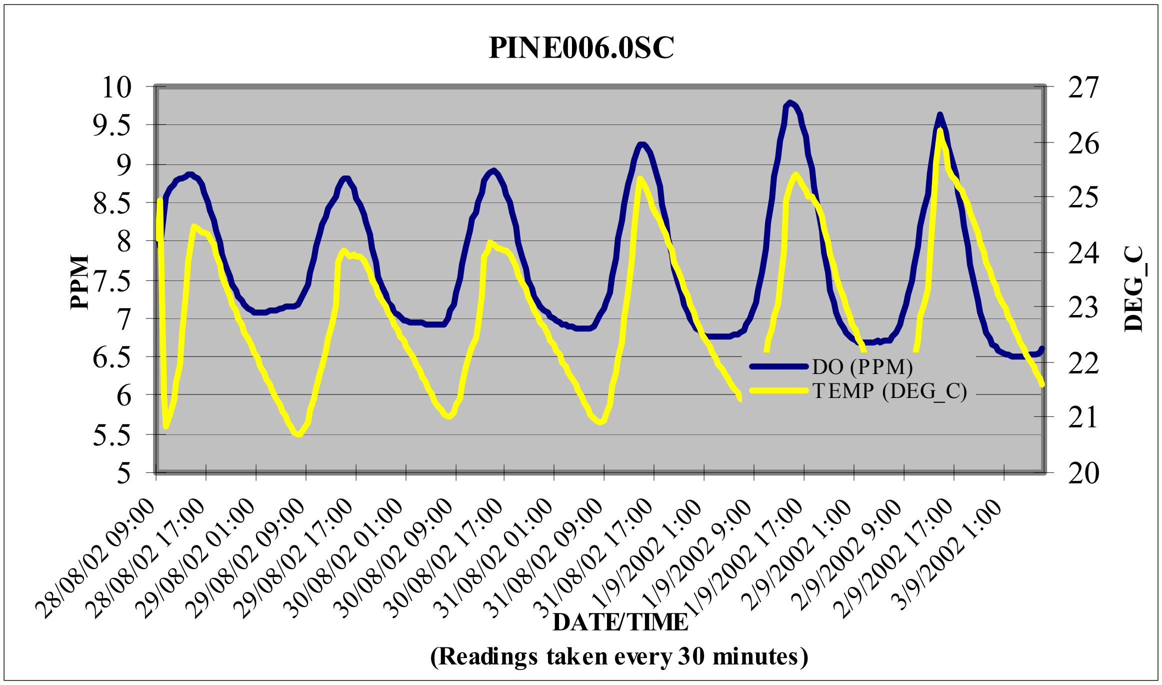


Figure 10: Diurnal dissolved oxygen and temperature data, Pine Creek test site, Cumberland Plateau (68a). Readings every 30 minutes for 142 hours.

Tennessee will continue to investigate how other factors are related to nutrient enrichment in streams. Tennessee has been awarded two 104(b)(3) grants that will add to the state's database and expertise in investigating nutrient enrichment. A probabilistic monitoring study investigating the impact of small impoundments on streams was began in Fall 2003. Monitoring will continue for one year and will include nutrient samples, suspended solids, turbidity, periphyton abundance, habitat assessments, canopy measures, dissolved oxygen monitoring and macroinvertebrate collections.

A second diurnal dissolved oxygen study will be conducted in summer 2004. This study will include nutrient sampling, macroinvertebrate collections and periphyton abundance surveys.

Information Needed For New Broad Basins Subecoregion (66j)

Tennessee was one of the first states in the southeast to have Level IV subecoregions delineated. In ecoregion 66, the Blue Ridge Mountains, four subregions were delineated in Tennessee: 66d (Southern Crystalline Ridges and Mountains), 66e (Southern Sedimentary Ridges), 66f (Limestone Valleys and Coves), and 66g (Southern Metasedimentary Mountains). The area of southeastern Tennessee known as the Copper Basin was included with subecoregion 66g.

Tennessee proceeded to identify and intensively monitor reference streams in each subregion. In 66g, our reference sites were five very high quality streams: the Middle Prong Little Pigeon River, the Little River, Citico Creek, North River, and Sheeds Creek. None of our reference streams for 66g were located in the Copper Basin, an area dramatically impacted by historical copper mining activities.

A few years later, the subecoregions of both North Carolina and Georgia were delineated. At that time, it was noted that areas similar to the Copper Basin appeared in both states. It was decided that these areas were distinct enough to warrant subecoregion status and were called subecoregion 66j, Broad Basins. In addition to the Copper Basin, 66j includes areas around the communities of Hiawassee and Blue Ridge, Georgia, plus Franklin, Canton, and Asheville in North Carolina.

Unlike the other subecoregions in Tennessee, we do not have a clear sense of what the biological integrity and nutrient goals should be in the Broad Basins. This information will be critical to our ability to set clean water goals, especially in light of ongoing restoration efforts in the Copper Basin. Unfortunately, due to the dramatic alterations of the Copper Basin area, suitable reference streams may not be available in Tennessee.

We have requested EPA assistance, along with our counterparts in North Carolina and Georgia, to help us identify suitable reference streams in subecoregion 66j and to collect data consistent with Tennessee's SOPs for biological surveys and chemical monitoring. (It may be that reference streams have already been established in these areas in Georgia and North Carolina.) For our part, we will perform the analysis of biological samples and will share the information with EPA, Georgia, and North Carolina. Additionally, we will seek suitable reference streams in the portion of 66j in Tennessee in the hope that some suitable sites occur outside of the impacted area.

We would also be available to assist in the reconning of potential sites in conjunction with North Carolina and Georgia. It is our view that these data would be helpful to all three states in setting nutrient goals.

Non-wadeable streams and rivers

Non-wadeable streams and rivers are covered under the general narrative nutrient criteria for fish and aquatic life in the 2004 water quality standards. Now that regional guidelines have been developed for wadeable streams and rivers, Tennessee is beginning to focus on non-wadeable flowing water. Because Tennessee feels strongly that nutrient criteria should consider the cause/effect relationships, biological guidelines for non-wadeable streams will be developed at the same time.

Nutrient and biological guidelines have already been developed for non-wadeable streams contained within the Loess Plains ecoregion (74a) and the Northern Mississippi Alluvial Plain (73a) as part of the wadeable streams criteria development.

It is likely that Tennessee will continue to use the ecoregion approach to establish nutrient criteria in these systems. Cause-effect relationships between nutrient concentrations and macroinvertebrates, and possibly including fish and algae, will be explored. Nitrate+nitrite, total phosphorus, turbidity and suspended solids data will also be analyzed. The first challenge will be to try and target reference reaches on these large systems. This will begin with a review of existing data (TDEC, TVA, USGS, USACE and others).

We intend to collaborate with other resource agencies in this effort. Individuals with expertise in large river water quality from TDEC, TVA, USGS, USACE and EPA will be contacted for review of strategies. Since TDEC does not currently have staff available or funding available for this activity, monitoring and subsequent criteria development in non-wadeable systems will be dependent on federal funds and/or assistance from other agencies.

One of the difficulties associated with non-wadeable streams and rivers is they often cross Level IV and even Level III ecoregional boundaries. Potential reference reaches in rivers crossing regions 65e and 74b have already been targeted and are being monitored as part of a federally funded 104(b) diurnal dissolved oxygen study currently underway. The reaches selected for study were fully supporting river reaches where existing macroinvertebrate data demonstrated a healthy community, habitat scores were high for the region and water quality data were within acceptable ranges.

Four stations were found to be meeting these guidelines: Hatchie River at mile 80.8, Wolf River at mile 44.4, South Fork Forked Deer River at mile 65.6, and the North Fork Forked Deer River at mile 20.5.

These four rivers represent all the major drainages that cross these two subregions, except the Obion and Loosahatchie where potential reference reaches could not be located based on existing data. The potential reference reaches are being monitored for diurnal dissolved oxygen, nutrients, flow, macroinvertebrates, temperature, conductivity and pH. In addition, fluvial geomorphological, canopy and habitat measurements are being taken.

For comparison, the same study is being conducted at five impaired sites on the Middle Fork Obion, North Fork Forked Deer, South Fork Forked Deer and Loosahatchie Rivers. These sites are also non-wadeable and drain ecoregions 65e and 74b. Results from this initial study will be used as a screening tool to help define reference condition in these difficult streams and to target additional reaches.

As funding allows, non-wadeable reference reaches will be targeted in other regions. When possible, these will be selected based on existing data. It is hopeful that 3 to 5 potential reference sites can be located in each targeted region.

If sufficient sites cannot be located based on existing data, field reconnaissance and screening of water quality and biological parameters will be used to supplement existing data. Once found, it is hopeful that federal funding will be provided to monitor these sites quarterly for at least three years. Ecoregions and groups of ecoregions that will be targeted for non-wadeable reference monitoring will be:

73a	Northern Mississippi Alluvial Plain (completed)
74b	Loess Plains (completed)
65e/74b	Loess Plains draining Southeastern Plains and Hills (initiated 2004)
65e	Loess Plains
71f	Western Highland Rim
71f/71h	Western Highland Rim draining Outer Nashville Basin
71h/71i	Outer Nashville Basin draining Inner Nashville Basin
71h/71g	Outer Nashville Basin draining Eastern Highland Rim
71i/71h	Inner Nashville Basin draining Outer Nashville Basin
67f	Southern Limestone/Dolomite Valleys and Low Rolling Hills
67f/67g	Southern Limestone/Dolomite Valleys and Low Rolling Hills draining Southern Shale Valleys
67g/67f	Southern Shale Valleys draining Southern Limestone/Dolomite Valleys and Low Rolling Hills
67f/66g	Southern Limestone/Dolomite Valleys and Low Rolling Hills draining Southern Metasedimentary Mountains
66g	Southern Metasedimentary Mountains
67f/66e	Southern Limestone/Dolomite Valleys and Low Rolling Hills draining Southern Sedimentary Ridges
66e/66d	Southern Sedimentary Ridges draining Southern Crystalline Ridges and Mountains

Lakes and Reservoirs

Lakes and reservoirs are covered under the general narrative nutrient criterion for fish and aquatic life established in the 2003 emergency rule. In 2004, Tennessee will consider initiating development of specific guidelines for lakes and reservoirs. Priority will be placed on large reservoirs (over 1000 acres) since more data are available for these large systems. Tennessee has 30 reservoirs over 1000 acres in size. Most of these are managed by either the Tennessee Valley Authority (TVA) or the U.S. Army Corps of Engineers (USACE). Six reservoirs are shared with other states.

It may be that there is not enough existing data available for large systems. Additional data collection in large systems and guidelines for smaller systems (<1,000 acres) will be undertaken as funding becomes available.

Tennessee intends to work closely with TVA, USACE, USGS and other agencies to develop reservoir criteria. Bordering states will be included for shared reservoirs (Alabama, Kentucky, Mississippi and Virginia). It is unlikely that Tennessee will choose to adopt EPA's national criteria recommendations for lakes and reservoirs. Instead, for large lakes and reservoirs, we will seek to develop site-specific goals. As with nutrient development in wadeable streams, we will attempt to link cause and effect relationships.

The initial phase of reservoir criteria development, which has already begun, is a data search and compilation to target data gaps and monitoring needs. The majority of available data has been be provided by TVA and USACE. TVA conducts vital signs monitoring on 18 reservoirs (Dycus and Baker, 2001). Data that may be pertinent to developing nutrient criteria include secchi disc, temperature, pH, DO, conductivity, chlorophyll, nutrients, TOC, benthic macroinvertebrates and fish. These parameters will be used to help determine if there are reservoirs that can be used to establish a reference condition for nutrient enrichment.

The U.S. Army Corps of Engineers collects the same data, except fish and macroinvertebrates on the seven lakes they manage in Tennessee. They have macroinvertebrate data on five of these lakes. However, sampling techniques are different from TVA and may not be comparable.

Once all the existing data have been compiled, the time frame for criteria development will be dependent on data availability, sampling needs, the comparability of biological sampling protocols and how much additional sampling can be provided by TVA and USACE. TDEC is interested in using embayment areas in nutrient criteria development and assessment of lake health. TVA has already indicated they will not be able to assist with embayment monitoring as these areas are not included in their vital signs monitoring. TDEC views embayment areas as critical to understanding reservoir loadings and nutrient criteria development. If the state must collect data, federal funding will be necessary and criteria development may be delayed.

Until these preliminary tasks are accomplished, it is uncertain how lakes and reservoirs will be grouped for criteria development. Although the ecoregion framework will be evaluated, it is unlikely that this classification system alone will be adequate for developing criteria. Other factors such as retention times, seasonal management, and depth will have to be considered.

The next phase of nutrient development for lakes and reservoirs will be those reservoirs between 200 and 1000 acres. Tennessee has 56 impoundments of this size. This includes TVA reservoirs (primarily flood control), most of the impoundments managed by TWRA (Tennessee Wildlife Resource Agency) for fishing, the majority of state park lakes, many municipal lakes and some private developments. Most of the existing data on these lakes were collected during the clean lakes program in the early nineties. Very little recent data are available.

Several of these lakes were included in a survey of forty selected lakes and reservoirs as part of the clean lakes assessment program (Hansel et al, 1992). This study also included some of the large reservoirs and was designed to determine trophic status. Based on this study, none of the lakes were dystrophic, 16 were mesotrophic, 9 were eutrophic and 15 were hypereutrophic.

Another study was conducted on 15 mid-sized lakes as well as the stream reach immediately downstream of the dam in 1996. This study indicated many of these impoundments were enriched and/or were contributing to the loss of downstream uses (Arnwine, 1996).

Ecoregion boundaries may be a more useful framework for establishing guidelines in these moderately sized systems. Most are contained within a single ecoregion (or even subregion). Lake management will need to be considered, especially the TWRA lakes, which are routinely fertilized. It is likely that TDEC will use stream data immediately downstream of the impoundments to establish guidelines to insure protection of both systems.

A data search will be conducted to determine what is available and what is needed to develop nutrient criteria for these systems. Once needs are targeted, federal funding will be necessary to perform sampling. The parameters that will be evaluated include chlorophyll, secchi readings, turbidity, nutrients, dissolved oxygen and macroinvertebrates. Fish are considered less appropriate since many of these lakes are stocked and do not have ecologically balanced assemblages. Also, previous comparison studies in impaired systems have shown fish tend to be less sensitive to nutrient enrichment than macroinvertebrates.

Reservoirs less than 200 acres will be treated separately (unless data show these are similar to the moderately sized impoundments). Tennessee has 1,151 reservoirs under 200 acres. These include one TVA reservoir, municipal lakes, state parks, city parks, resorts, community developments, farm ponds and private lakes.

There is little historic data on many of these small impoundments. Although small, they are often in headwater areas and have the potential to affect downstream areas. It is possible that an emphasis on downstream impacts, especially in the smaller impoundments, will prove most appropriate.

A probabilistic study using 104(b)(3) grant monies was initiated in fall 2003 to evaluate water quality in streams below 75 of these impoundments. Monitoring was completed in summer 2004. Data are currently being analyzed. Nutrient, dissolved oxygen, periphyton and macroinvertebrate data generated as part of this study can be used to help determine the effect of small impoundments on stream nutrient loading and use support. This will also help target impoundments that are not adversely affecting downstream biota and may be used to determine protective levels of nutrients in small impoundments.

If additional federal funding is available, these impoundments as well as downstream reaches will be monitored for three years to establish nutrient levels that support designated uses. Additional impoundments will be selected based on review of existing biological data of downstream reaches and field reconnaissance for any large ecoregions where suitable impoundments were not located during the probabilistic study. Selection of suitable impoundments for nutrient criteria development will be based primarily on downstream biotic assemblages. Ideally, three to five impoundments will be targeted in each bioregion (15).

Impoundment monitoring will include, at minimum, nutrients, turbidity, secchi reading, macroinvertebrates, chlorophyll, temperature and dissolved oxygen. The same parameters will be measured downstream of the impoundment. The large reservoir work-group will be asked to review the small to medium impoundment strategy as it is developed.

Wetlands

Like reservoirs, wetlands are covered under the emergency nutrient rule promulgated in 2003 and approved by EPA. Specific nutrient criteria for wetlands are being deferred at this time until more guidance is provided by EPA.

At this time, we are uncertain what approach might be best for nutrient criteria development for wetlands. It may be possible to select reference quality wetlands based on wetland functions.

PUBLIC PARTICIPATION AND PEER REVIEW PROCESS

In general, public participation for nutrient criteria development is conducted as part of TDEC's rule revision/adoption process. This involves public notices, public hearings and receiving comments from the public regarding the proposed changes to the rules.

All findings are published and made available to the public through the department's web site, mailings and various public meetings. Additionally, many of our publications are housed at the 13 state document repositories. These repositories include the state library and archives, state university, and public libraries.

When funding for travel is available, TDEC staff present findings and papers to professional organizations. In the past, presentations have been given at meetings such as the Region 4 Regional Technical Advisory Group (RTAG), the TNAWRA (Tennessee Section of the American Water Resources Association) and SWPBA (Southeastern Water Pollution Biologists Association).

TDEC is considering forming a reservoirs workgroup for the purpose of gathering input and peer review from individuals who have expertise in limnology, reservoir management and other fields related to nutrient criteria development. The group will most likely be composed of representatives from TVA, USACE, TWRA, academia and TDEC. A similar work-group will be developed for large rivers.

TDEC has dedicated time and staff to actively participate as a state member of the EPA Region 4 Regional Technical Advisory Workgroup (RTAG).

VI. TIMELINE

This timeline outlines the steps TDEC has taken since 1995 as well as future goals in nutrient criteria development. The plan is resource intensive and represents only a small portion of staff responsibilities. This plan is dependent on availability of additional federal resources being provided to the state. Due to budget constraints, changes in priorities, or personnel availability, plans may not progress on schedule.

This timeframe presents the ideal process and is dependent on additional federal funding. Obviously, future activities are subject to revision.

1995

Initiation of ecoregion delineation and reference stream targeting.

Initial field reconnaissance of potential reference streams.

1996

Intensive reference stream monitoring.

Monitoring of 15 moderate size lakes as part of the clean lakes program.

1997

Intensive reference stream monitoring.

1998

Intensive reference stream monitoring.

1999

Intensive reference stream monitoring ends. (Monitoring continues in conjunction with the 5-year watershed cycle.)

TDEC staff members Denton and Wang participate in national workgroup for development of nutrient criteria for rivers and streams.

2000

Publication of *Tennessee Ecoregion Project* (Arnwine et al, 2001).

Data reduction for regional nutrient criteria development of wadeable streams and rivers.

Data reduction of macroinvertebrate data for development of regional biological criteria

Publication of EPA national nutrient criteria document for rivers and streams. Document contains a case study from Tennessee/

2001

Probabilistic study of 50 streams in the Inner Nashville Basin initiated.

Publication of *Development of Regionally-Based Interpretations of Tennessee's Narrative Nutrient Criterion* (Denton et al, 2001).

Publication of *Development of Regionally-based Numeric Interpretations of Tennessee's Narrative Biological Integrity Criterion* (Arnwine and Denton, 2001).

Staff proposal for initiation of triennial review process. Promulgation of numeric nutrient and biological integrity criteria recommended.

2002

Continuation of probabilistic study with added emphasis on nutrient and macroinvertebrate relationships.

Continuation of triennial review process for nutrient and biological criteria.

2003

Rulemaking process is initiated for water quality criteria revisions.

Emergency narrative nutrient criteria is promulgated by the Board, then approved by EPA.

Based on EPA and public concerns, nutrient criteria and biological integrity proposal is changed from numeric to narrative with numeric guidelines referenced.

Promulgated rulemaking hearing rules, including narrative nutrient criteria for protection of fish and aquatic life and recreation in all types of waterbodies is submitted to EPA for approval.

Publication of *Probabilistic Monitoring in the Inner Nashville Basin with Emphasis on Nutrient and Macroinvertebrate Relationships* (Arnwine et al, 2003).

Publication of *Nutrient Levels, Periphyton Densities and Diurnal Dissolved Oxygen Patterns in Impaired and Reference Quality Streams in Tennessee* (Arnwine and Sparks, 2003).

Initiation of probabilistic monitoring of 75 streams below small impoundments.

2004

New water quality standards, including narrative nutrient criteria referencing regional guidelines and revised biological criteria, become a state regulation.

Nutrient criteria development plan drafted and submitted to EPA for comments.

EPA approves water quality standards including narrative nutrient criteria for all waterbodies with regional guidelines for wadeable streams as well as the biological criteria, which are referenced in nutrient criteria. EPA takes no formal action on the proposed flow basis for application of nutrient criteria.

Initiation of new diurnal dissolved oxygen, periphyton, and nutrient study. New project includes study of non-wadeable streams in two ecoregions.

Completion of monitoring for probabilistic study of streams below small impoundments.

Revised nutrient criteria document resubmitted to EPA.

2005

Retrieval and compilation of existing data for large reservoirs. Identify data gaps. Determine appropriate research methods. Determine additional data study needs. Identify resource requirements necessary for study completion. Use outside assistance where possible. Work with TVA, USACE and other states to get additional data and formulate classification and nutrient development plan. Obtain funding for monitoring if supplemental data needed.

Data gathering and review for non-wadeable rivers. Target potential reference reaches or identify a non-reference approach. Determine additional monitoring needs. Work with other agencies and states to get additional data.

Data evaluation and publication of reports on probabilistic monitoring below small impoundments and dissolved oxygen study. Use dissolved oxygen study to help target reference reaches in non-wadeable streams in west Tennessee. Use impounded stream study to evaluate background nutrient levels in small to medium impoundments.

Initiate next triennial review of water quality standards. Explore interest in revival of numeric stream criteria recommendaton.

2006

Begin monitoring large reservoirs including embayment areas to fill data gaps as needed. Tennessee will be dependent on TVA and USACE for the bulk of this activity. Timeline will be dependent on availability of these agencies to assist or federal funding if they are not available. (TVA has already indicated they will likely not be able to assist with embayment monitoring.)

Begin monitoring reference reaches of large rivers (dependent on funding and staff availability)

Complete promulgation of revised water quality standards, including numeric stream criteria, if recommended.

2007

Continue monitoring of large reservoirs including embayment areas to fill data gaps as needed, continue data analysis for criteria development (dependent on outside assistance or funding).

Continue monitoring reference reaches of large rivers (dependent on funding)

2008

Continue monitoring reference reaches of large rivers (dependent on funding)
Begin small impoundment monitoring (dependent on funding). Enlist help of TWRA, state parks and municipalities if possible.

Continue monitoring of large reservoirs including embayment areas to fill data gaps if needed, continue data analysis for criteria development (dependent on outside assistance or funding).

Use data from probabilistic study and historic data to determine monitoring needs to develop criteria for impoundments under 1000 acres.

Initiate next triennial review of water quality standards, including lakes nutrient criteria for large reservoirs (>1,000 acres).

2009

Complete data analysis and evaluation of large reservoir and embayment monitoring. Draft nutrient and biological guidelines for large reservoirs (and possibly chlorophyll or other related criteria if warranted based on data).

Complete data analysis and evaluation of large river monitoring data. Draft nutrient and biological guidelines for large rivers.

Begin small to medium impoundment monitoring (dependent on funding). Enlist help of TWRA, state parks and municipalities if possible.

Complete revisions to water quality standards, including lakes nutrient criteria for large reservoirs (>1,000 acres).

2010

Continue small impoundment monitoring (dependent on funding). Enlist help of TWRA, state parks and municipalities if possible.

2011

Continue small impoundment monitoring (dependent on funding). Enlist help of TWRA, state parks and municipalities if possible.

Initiate next triennial review of water quality standards, including lakes nutrient criteria for small impoundments (<1,000 acres).

2012

Analysis and review of data from small impoundments. Draft nutrient and biological criteria (and possibly chlorophyll or other nutrient related criteria) if warranted by data evaluation for impoundments less than 1000 acres.

Initiate next triennial review of water quality standards, including lakes nutrient criteria for small impoundments (<1,000 acres).

VII. NEEDS ASSESSMENT FOR TENNESSEE'S NUTRIENT CRITERIA DEVELOPMENT PROGRAM

Tennessee has traditionally had a strong water quality monitoring, assessment and criteria development program. In the last seven years, water quality monitoring and related activities have increased by more than 400%. New procedures such as diurnal, dissolved oxygen monitoring, rapid periphyton surveys and probabilistic monitoring have been used to supplement targeted biological and water quality monitoring.

Despite the increase in water quality activities, there has not been an increase in staffing during this period. In 1998 through 2004, 94 personnel were assigned in whole or part to water quality monitoring and assessment activities (including both technical and support staff). The increased ability to conduct monitoring, assessments and criteria development without a net increase in the number of positions has been a result of standardization of methods, replacing intensive surveys with rapid field techniques, improved technology and shifting priorities from other programs.

Approximately \$3.7 million, (\$1.5 million federal) were allocated to cover salaries and benefits to support this program in 1998. The costs had risen to \$4.5 million in 2004 for the same number of staff. Another \$1.7 million is spent on travel, printing, utilities, communications, maintenance, professional services, supplies, rent, insurance, vehicles and equipment in support of this program.

The funding necessary to maintain the current program has also risen steadily. This is due to rising lab expenditures from increased sample collections, use of lab personnel for field support and rising analytical costs. The amount spent on laboratory activities has more than doubled from $0.6 million in 1998 to $1.3 million in 2003.

As always, the Division is interested in improving its water quality assessment program and serving the public by protecting the waters of Tennessee. It is evident that Tennessee already spends a great deal of time, effort and money on water quality monitoring. However, a significant funding gap does exist if EPA requirements and guidance for nutrient criteria development are to be met. Without a steady source of federal funding **in addition** to current funding, it is not likely that the monitoring needed for nutrient criteria development and assessment for non-wadeable rivers, reservoirs or lakes will be feasible.

Additional staffing and funding must be permanent and not in the form of competitive or temporary grants to expand programs. TDEC is not expecting additional funding from other sources for these activities over the next ten years. As mentioned previously, it does not appear that TVA will be able to provide as much monitoring support as anticipated especially in embayment areas. Therefore, federal funding increases would be vital for implementation of all or part of the nutrient criteria goals. The following outlines the staff, equipment and additional federal funding that would be necessary to implement a criteria development, monitoring and assessment plan for rivers and reservoirs.

Personnel costs are based on average year expenses per full-time employee and includes salary, longevity, benefits, travel, printing, maintenance, professional services, supplies, rent and insurance, vehicle operation, equipment and services. The amount $66,760.00 is currently used by the division to estimate the typical costs for a full time technical employee for Tennessee for budget planning purposes.

Indirect costs are listed separately at the FY 2004 rate of 24.3% (rate is recalculated annually). Laboratory analyses are based on the FY 2004 pricing list provided by the Environmental Laboratories, Tennessee Department of Health.

The estimated costs would include a full reservoir water quality program including criteria development, monitoring in support of criteria development as well as 305(b) and 303(d) assessments, TMDLs and data management. Activities would continue to be coordinated with other agencies performing reservoir and river monitoring to share resources and to prevent duplication of efforts.

Additional Annual Funding needed: $1,531,722
Plus $90,000 one time purchase for equipment to start program.

Additional Field Staff needed:	12 biologists (two in each of six field offices)
Additional Central Office Staff:	Biologist in Planning and Standards Section (criteria development, monitoring coordination, data management, water quality assessments) 2 Environmental Protection Specialists in the Watershed Management Section (TMDLs).

Personnel = $1,001,400

Indirect = $230,322

Laboratory analysis = $300,000

Equipment Needs =	3 boats (one time purchase) = $90,000 (1 to be shared by field offices in each of the three main regions of the state east, middle, and west)

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APPENDIX A

Division of Water Pollution Control Responses to EPA Comments

EPA Comment: Comparison of the state's proposed level IV ecoregion nutrient criteria to the national ecoregional criteria recommendations indicates that the state proposed levels are generally substantially in excess of the national recommendations.

We do not believe that a direct comparison of the state's subregional (Level IV) nutrient data to the national Level III ecoregion data is appropriate. Many of the data from the Level IV subregions are statistically different from the larger Level III ecoregion at the state level. The national database contains subregions not even found in Tennessee. Our Level III ecoregions were delineated into subregions in order to provide this more accurate and localized assessment process.

Additionally, EPA's National Database included data from large rivers and non-wadeable streams that cross Level IV ecoregion boundaries. The state reference database was restricted to wadeable streams that had at least 80% of the upstream drainage included within the targeted subregion. Therefore, the state data are much more refined and indicative of local conditions and stream size. Tennessee plans to develop separate guidelines for large rivers and non-wadeable streams that are more pertinent to these systems.

Tennessee's regional nutrient guidelines for wadeable streams are based on nine years' data (1995-2003), roughly the same spread of years as EPA's national study. Tennessee's use of reference streams at the level IV (ecological subregion) follows EPA's recommendation that State's develop localized criteria whenever possible.

EPA Comment: In the Sequatchie Valley (68b) the nitrate +nitrite and TP proposals are higher than the recommendation for the Southwestern Appalachians.

The Sequatchie Valley is a very small and unique area found only in Tennessee and Alabama. It is considerably different than the other areas of the Southwestern Appalachians. In fact, the Sequatchie Valley is sometimes considered part of ecoregion 67, the Ridge and Valley (Griffith, 1997).

Both TP and NO2+NO3 levels data in 68b were significantly different from subregions 68a and 68c, the other two areas of the Southwestern Appalachians in Tennessee. It is unlikely that it was well represented in the national database compared to the amount of data from the rest of the Level III ecoregion, which also includes subregions not found in Tennessee.

EPA Comment: In the Southern Igneous Mountains and Ridges (66d) nitrate+nitrate proposal is higher than national recommendation for the Blue Ridge. The subregion has a much larger area in NC.

The proposed total phosphorus criterion in this region was in line with the national recommendations for the Blue Ridge Mountains. The proposed NO2+NO3 levels were higher than the national criterion. This is not surprising since this subregion tested significantly different from the other three Blue Ridge subregions in Tennessee for this parameter.

The five ecoregion reference sites in this region are all on protected lands in the Cherokee National Forest or Roan Mountain State Park. Land use is 92-100% forested upstream of the reference sites so it is likely the NO2+NO3 levels measured at these sites represent natural background conditions.

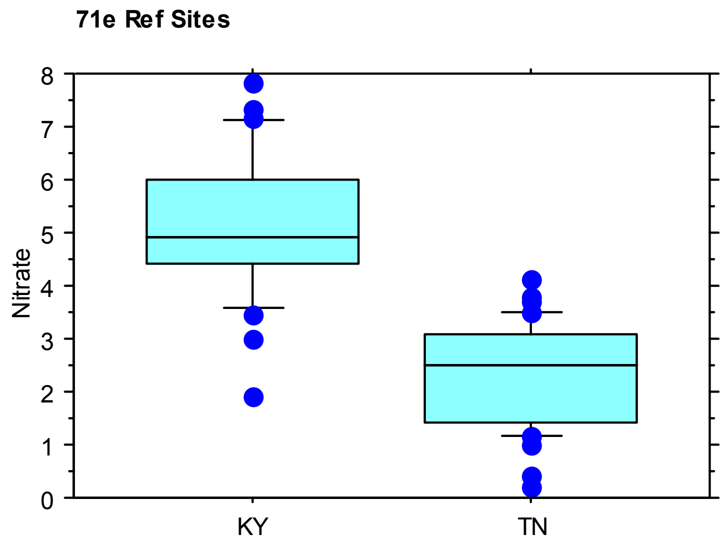
EPA Comment: In the Inner Nashville Basin (71i) TP proposal is higher than national recommendation for Interior Plateau.

The Inner Nashville Basin is unique to Tennessee. The total phosphorus levels are not comparable to any of the other regions in Tennessee and should not be compared to the entire Interior Plateau on a national level. This region is naturally high in phosphorus. Tennessee has data from seven reference sites (105 samples) representing four major watersheds in this region so the background phosphorus levels are well documented.

EPA Comment: In the Western Pennyroyal Karst (71e) nitrate+nitrite is higher than the national recommendation for the Interior Plateau. This subregion is mostly in Ky.

This region only occurs in Kentucky and Tennessee. Background NO2+NO3 levels are naturally very high in this region and should not be compared to the rest of the Interior Plateau (Level III). In response to EPA's concerns, Kentucky reference data were compared to Tennessee's data to verify the high levels of nitrates being observed in reference streams (Figure 6). Kentucky data were higher than Tennessee's. We believe that this information supports the proposed criteria levels, since this region occurs in no other states.

A comparison of Kentucky reference stream data to Tennessee's is presented on the next page.



71e Ref

	Nitrate, Total	Nitrate, KY	Nitrate, TN
Mean	3.498	5.146	2.280
Std. Dev.	1.858	1.381	.965
Std. Error	.227	.256	.159
Count	67	29	37
Minimum	.190	1.930	.190
Maximum	7.830	7.830	4.110
# Missing	1	0	1
Median	3.150	4.920	2.520

Results for totals may not agree w ith results for individual cells because of missing values for split variables.

Percentiles
Split By: State

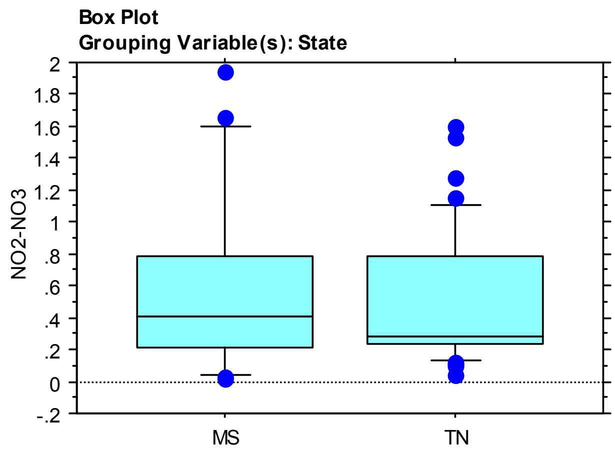
	Nitrate: Total	Nitrate: KY	Nitrate: TN
10	1.332	3.566	1.176
25	1.935	4.428	1.430
50	3.150	4.920	2.520
75	4.750	5.998	3.087
90	6.102	7.140	3.480

Results for totals may not agree w ith results for individual cells because of missing values for split variables.

Figure 6: Comparison of Nitrate (KY) and Nitrate+Nitrite (TN) levels at reference streams in Ecoregion 71e. Note: TN is Nitrate+Nitrite

EPA Comment: In 74b, the Mississippi Valley Loess Plains nitrate+nitrite proposal is higher than national recommendation for Mississippi Valley Loess Plains, considerably larger area in Mississippi.

Nitrate+nitrite levels in this subregion were significantly higher than the only other 74 subregion in Tennessee (74a – Bluff Hills). Therefore the values for Tennessee should only be compared to data in 74b not the entire Level III ecoregion. The national database included larger rivers that crossed ecoregions. In response to EPA's comments, the NO2+NO3 data from 74b reference streams in Tennessee were compared to those in Mississippi where this region is considerably larger (Figure 7). Ranges were comparable with the median levels in Tennessee reference streams being lower indicating the proposed criteria are appropriate.



Descriptive Statistics
Split By: State

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	Median
NO2-NO3, Total	.514	.455	.061	55	.020	1.940	.320
NO2-NO3, MS	.579	.555	.139	16	.020	1.940	.405
NO2-NO3, TN	.487	.412	.066	39	.040	1.600	.280

Results for totals may not agree w ith results for individual cells because of missing values for split variables.

Percentiles
Split By: State

	NO2-NO3: Total	NO2-NO3: MS	NO2-NO3: TN
10	.120	.040	.128
25	.240	.210	.240
50	.320	.405	.280
75	.787	.785	.787
90	1.150	1.596	1.102

Results for totals may not agree w ith results for individual cells because of missing values for split variables.

Figure 10: Comparison of nitrate+nitrite levels of Mississippi and Tennessee reference streams in the Mississippi Loess Plains

EPA Comment: In 67g, the Southern Shale Valleys, the TP proposal is higher than national recommendation for Ridge and Valley.

Total phosphorus data in the Southern Shale Valley subregion were statistically different from the other three Ridge and Valley subregions in Tennessee. Since the national database is an aggregate of data from all subregions in the Ridge and Valley ecoregion, it should not be directly compared to this distinct subregion.