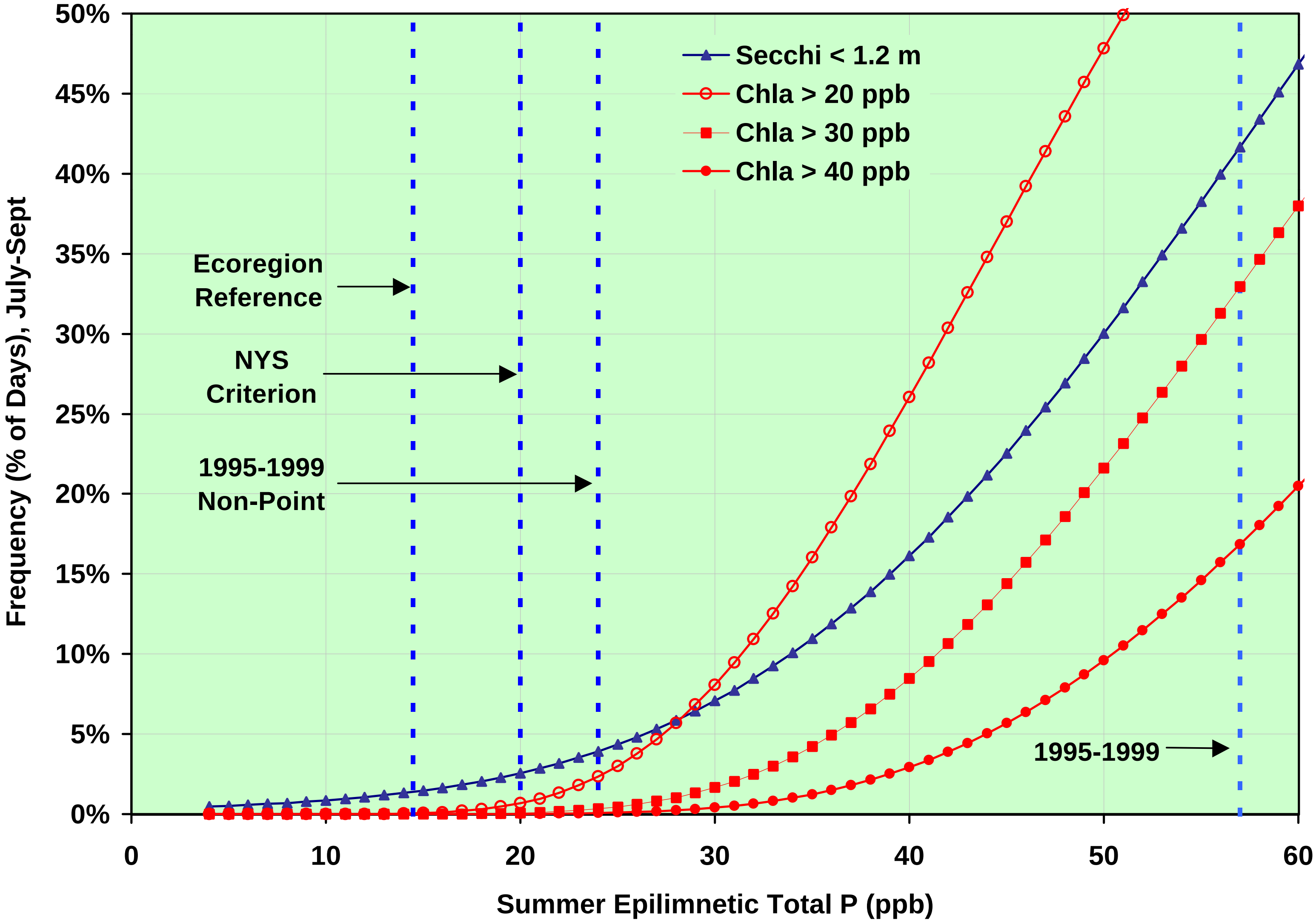
Phosphorus Criteria for Onondaga Lake



EPA United States Environmental Protection Agency Office of Water

WATER QUALITY CRITERIA & STANDARDS

National Nutrient Criteria Development

This website is intended for State, Tribal and EPA Regional water quality managers that are working with EPA to develop National Nutrient Criteria. General pages regarding water and water quality can be located from the Office of Water's Water Topics page.

National Nutrient Strategy
The EPA's National Nutrient Strategy Document, released July 1998.

Ecoregional Nutrient Criteria
Water quality criteria for 17 specific geographic regions (ecoregions) of the United States addressing lakes and reservoirs, rivers and streams, and wetlands.

Nutrient Ecoregion Map
Color map of the Nation's 14 aggregated nutrient ecoregions.

National Nutrient Team
Names and contact information of the National Nutrient Team members by organization.

EPA Regional Nutrient Coordinators
Names and contact information of the EPA Regional Nutrient Coordinators listed by Region.

National Nutrient Guidance Documents
Waterbody specific guidance documents for developing nutrient criteria.

Nutrient Database **(user only, password protected)**
Water quality data from states and ecoregions of the proposed nutrient parameters.

Peer Review Comments
Peer review comments on the EPA's National Nutrient Strategy Document, released July 1998.

Public Comments
Public comments on the EPA's National Nutrient Strategy Document, released July 1998.

Past, Present, and Future Meetings and Events
Meeting information for Regional and National Nutrient Team Meetings.

Please send correspondence for the Rivers and Streams guidance document to OW-GENERAL@epa.gov.

URL: http://www.epa.gov/OST/standards/nutrient.html
Revised August 14, 2000

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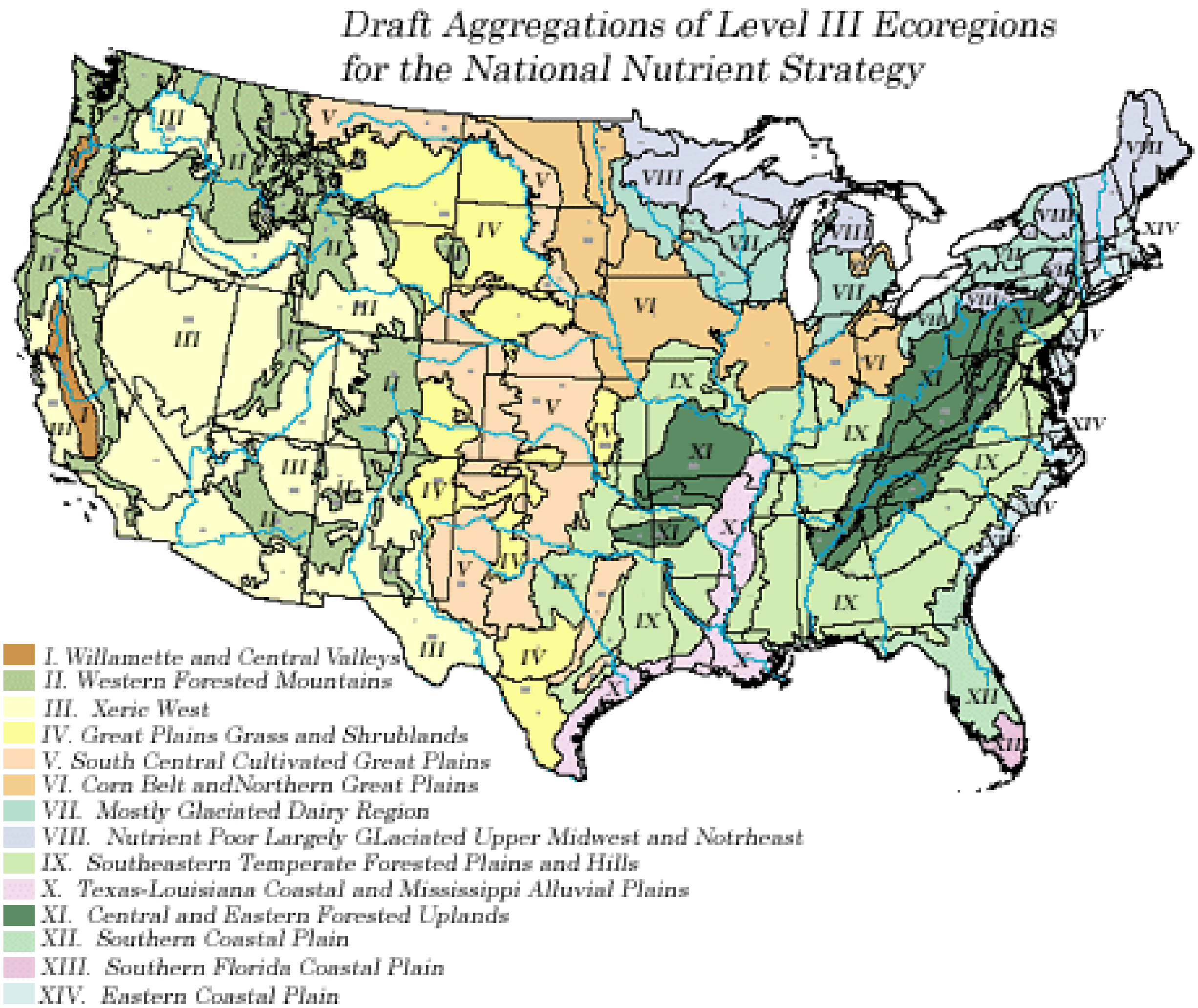
WATER QUALITY CRITERIA & STANDARDS



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WATER QUALITY CRITERIA & STANDARDS

National Nutrient Guidance Manual: Lakes and Reservoirs

The Nutrient Criteria Technical Guidance Manual: Lakes and Reservoirs is one in a series of waterbody-specific documents that support the President's Clean Water Action Plan and the National Nutrient Strategy. The intent of these documents is to provide States and Tribes with methods to assess waterbody nutrient impairment and develop ecoregion-specific nutrient criteria.

- Fact Sheet
- *Federal Register* Notice (May 23, 2000)
- Download entire document (PDF, 7M)
- Summary of Peer and Public Comments (June 23, 2000)

Guidance Manual: Lakes and Reservoirs

- Cover Page, Table of Contents (PDF, 744K)
- Chapter 1: Introduction (PDF, 710K)
- Chapter 2: Basis for Lake and Reservoir Nutrient Criteria (PDF, 316K)
- Chapter 3: Preliminary Steps for Criteria Development (PDF, 96K)
- Chapter 4: Establishing an Appropriate Database (PDF, 101K)
- Chapter 5: Candidate Variables for Criteria Setting (PDF, 334k)
- Chapter 6: Identifying and Characterizing Reference Conditions (PDF, 637K)
- Chapter 7: Nutrient Criteria Development (PDF, 775K)
- Chapter 8: Using Nutrient Criteria to Protect Water Quality (PDF, 468K)
- Chapter 9: Modeling Tools (PDF, 920K)
- References (PDF, 70K)
- Appendix A: Nutrient Region Descriptions (PDF, 37K)
- Appendix B: Case Studies (PDF, 2M)

All files are in PDF format. In order to read them, you must have Adobe Acrobat Reader 3.0 or higher installed on your computer.

United States
Environmental Protection
Agency

Office of Water
Office of Science and Technology
Washington, DC 20460

EPA-822-B00-001
April 2000
www.epa.gov

Nutrient Criteria
Technical Guidance Manual

Lakes and Reservoirs

First Edition

Natural enrichment ranges throughout these magnitudes of concentration according to geographic and geological regions of the country. Consequently, it would be necessary to determine the natural ambient background for each lake so that the eutrophication caused by human development and abuse can be addressed. Addressing this cultural eutrophication is the objective of this manual, but the development of nutrient criteria on a lake-by-lake basis may be prohibitively time consuming and expensive for States and Tribes.

Alternatively, these lakes or reservoirs can be divided into regionally similar groups based on their physical characteristics within a proximal geographic area. Those lakes of each established group having the least land development or other human impact can be identified as the reference lakes for measuring relatively undisturbed nutrient conditions appropriate for that class and region. This reference condition information, within an appropriate historical context and objectively interpreted, then can become a candidate criterion for use as a benchmark against which other similar lakes may be compared. Before the criterion is finally established, however, the scientists and resource managers involved should assure themselves that it also will have a beneficial or at least neutral downstream effect on the lakes, reservoirs, streams, or estuaries within or just below the area of application. This concept, as illustrated in Figure 1.1, is essentially the basis for the National Nutrient Criteria Program and is described variously throughout this text.

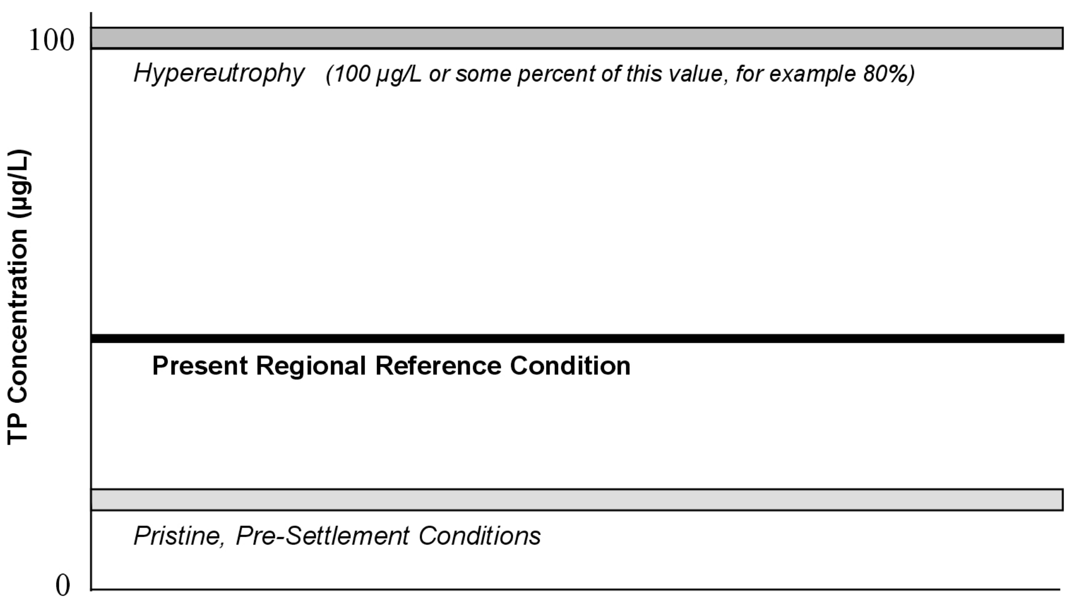

Figure 1.1. Conceptual basis for the National Nutrient Criteria Program using TP as an example variable.

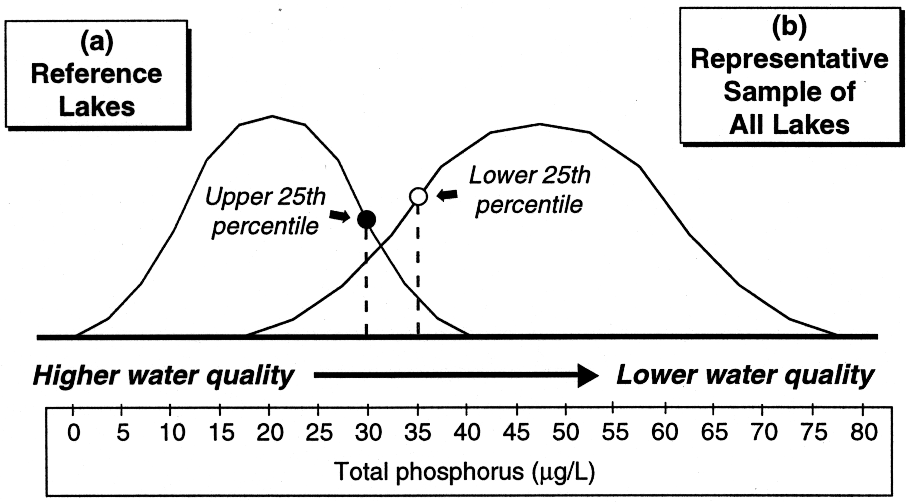

Figure 1.4. Two approaches for establishing a reference condition value using total phosphorus as the example variable.

The choice of the upper 25th and the lower 25th percentiles for the selected reference lakes and the random sample reference or census of all lakes in a class, respectively, is a rational but qualitative decision. It represents the effort to avoid imposing an undue penalty on high-quality mesotrophic lakes in regions where the lakes are predominantly oligotrophic. By selecting an upper percentile of the reference lakes, there is a greater likelihood that more of the broader population of lakes will comply.

Conversely, in regions of intense cultural enrichment, a lower percentile of the distribution of the remaining lakes used as reference must be selected to avoid establishing criteria based on degraded conditions. The quarterly increments were chosen as a reasonable division of the data sets recognizable by the public, and the upper 25th percentile and lower 25th percentile as reasonable and traditional fractions of the range and frequency of distribution. This approach promotes water quality enhancement and has broad application over the country.

Although these quantitative values are believed appropriate to the objective of the program, we recognize that some variation about such percentiles may be necessary. Certainly, in severely degraded areas even a 25th percentile may be insufficient, and some lower fraction of the remaining reference values may be required. On the other hand, where all lakes or reservoirs are in remarkably good condition relative to cultural enrichment, the acceptable fraction of the reference condition may be justifiably increased. The key point here is the presentation of a defensible scientific rationale for the determination. Otherwise, EPA presumes the above guidance will be appropriate.

It is intended that these two frequency distributions, with different quartiles, will produce a similarly appropriate reference condition—all other factors being equal. In either case, a number is generated that can be used as an initial reference preliminary to criteria development, and as a source of comparison for individual lakes in the class.

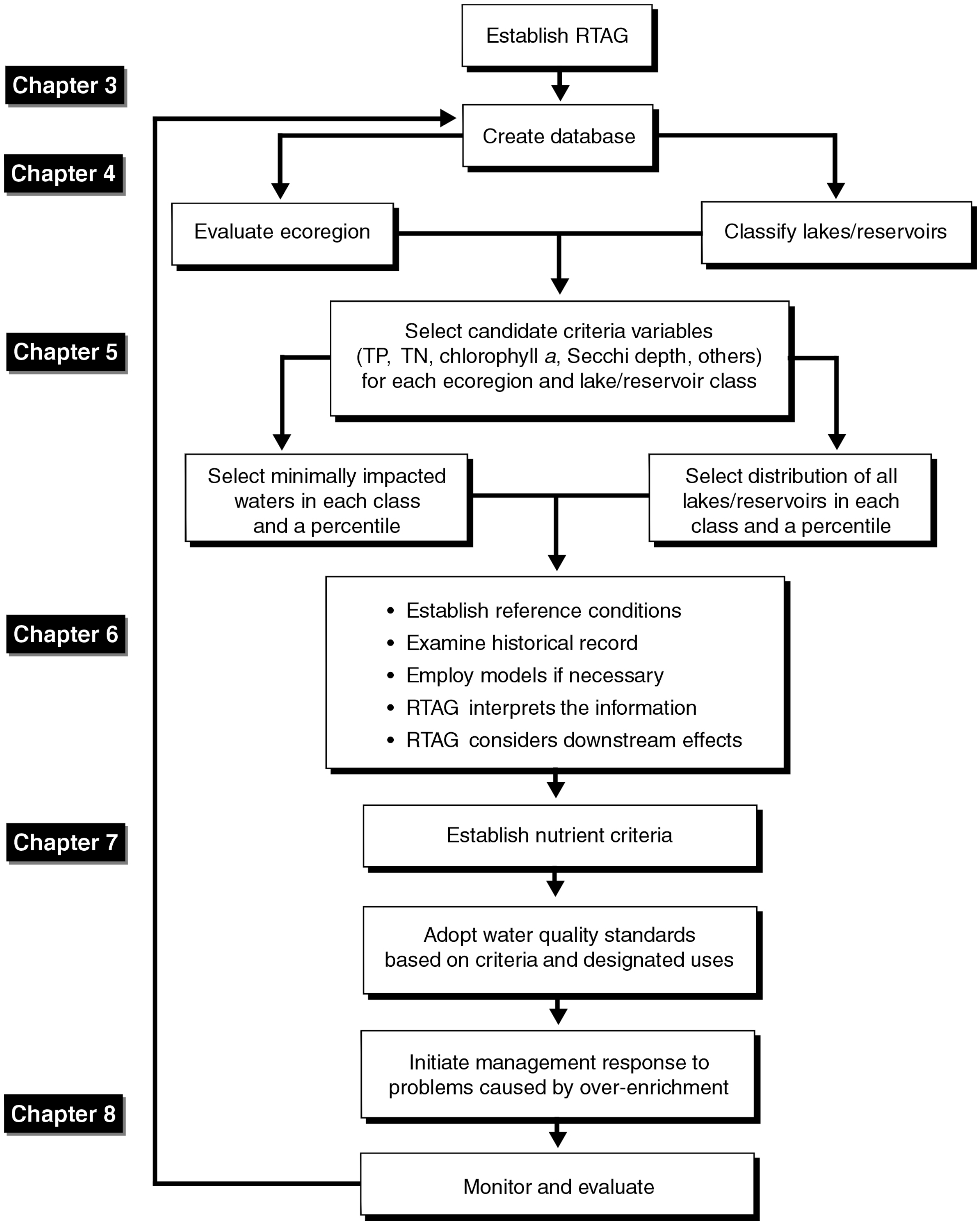

Figure 1.2. Flowchart of the nutrient criteria development process.

predation upon them as the density of zooplanktivorous fish increases, perhaps the result of alterations in the density of the macrophytes that give the fish shelter from their predators.

In general, fish yield increases as the productivity of the lake increases. However, there may be changes in the dominant fish species as a lake eutrophies (Oglesby et al., 1987) (Figure 5.1). In northern lakes, salmonids may dominate in clear lakes having oxygenated hypolimnia. When primary productivity increases to the point that the hypolimnion becomes anoxic, salmonids may disappear to be replaced by percids; percids then are replaced by centrarchids; and finally, at the highest nutrient concentrations, rough fish such as carp or bullheads prevail.

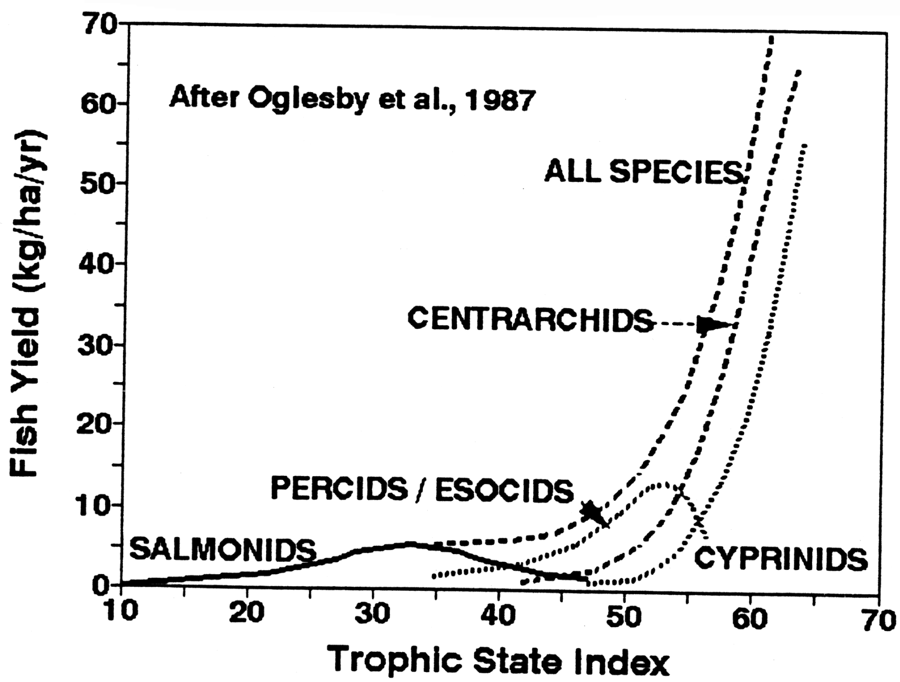

Figure 5.1. Changes in fish species yield with trophic state.

Also discussed below are general guidelines for developing criteria to protect selected designated uses. The values included here (and in Table 7.1) are *not* intended to represent proposed EPA or State ecoregional nutrient criteria. Rather, they illustrate ranges of parameters associated with the impairment of some traditional uses in some areas of the country. Criteria to protect these uses should be developed on a regional basis and should be consistent with EPA ecoregion criteria.

Table 7.1. Changes in Temperate Lake Attributes According to Trophic State (adapted from Carlson and Simpson, 1995)

TSI Value	SD (m)	TP (µg/L)	Attributes	Water Supply	Recreation	Fisheries
<30	>8	<6	Oligotrophy: Clear water, oxygen throughout the year in the hypolimnion			Salmonid fisheries dominate
30-40	8-4	6-12	Hypolimnia of shallower lakes may become anoxic			Salmonid fisheries in deep lakes
40-50	4-2	12-24	Mesotrophy: Water moderately clear but increasing probability of hypolimnetic anoxia during summer	Iron and manganese evident during the summer. THM precursors exceed 0.1 mg/L and turbidity >1 NTU		Hypolimnetic anoxia results in loss of salmonids. Walleye may predominate
50-60	2-1	24-48	Eutrophy: Anoxic hypolimnia, macrophyte problems possible	Iron, manganese, taste, and odor problems worsen		Warm-water fisheries only. Bass may be dominant
60-70	0.5-1	48-96	Blue-green algae dominate, algal scums and macrophyte problems		Weeds, algal scums, and low transparency discourage swimming and boating	
70-80	0.25-0.5	96-192	Hypereutrophy (light limited). Dense algae and macrophytes			
>80	<0.25	192-384	Algal scums, few macrophytes			Rough fish dominate, summer fish kills possible

TSI Range	TP Concentration	Aquatic Life
<TSI 40-50	TP = <24 µg/L	Salmonid fishery
TSI 50-60	TP = 24-48 µg/L	Percid fishery
TSI 60-80	TP = 48-192 µg/L	Centrarchid fishery
>TSI 70-80	TP = >192 µg/L	Cyprinid fishery

Such a fishery categorization may present problems because some warm-water fisheries would thrive in waters falling below the reference condition (i.e., 50 TSI). However, consultation with fisheries managers and the public through the water quality standards review process should help resolve the issue of robust fish in otherwise overenriched waters.

Drinking Water

Only in the past decade have we come to a full realization of the effect of eutrophication on drinking water (Cooke and Carlson, 1989). For years, the drinking water industry has recognized the effect of certain species of algae on taste and odor. However, trihalomethanes and other chlorinated byproducts also become connected with the effects of eutrophication (Palmstrom et al., 1988). It is now recognized that as a lake eutrophies, the species of algae will shift to those that affect taste and odor; these species will increase in density and increasingly affect the raw water quality. Turbidity will increase as the algae become more dense. The need to chlorinate then increases, and thus chlorination byproducts will increase as algae increase. Hypolimnetic anoxia will also increase the problems of iron and manganese control.

The reality is that drinking water plants must deliver a safe and potable product. As the effects of eutrophication are seen in the raw water, the cost of treatment increases. Unfiltered systems must give way to filtered water, then powdered carbon, and finally activated carbon. The run times of filters and of GAC filters decrease with increased algal densities. In short, eutrophication dramatically changes the cost and even the treatment process itself.

Several points along the trophic state continuum are relevant for drinking water supplies. The first is at a trophic state index (TSI) of 40 to 50, when the hypolimnion becomes anoxic. This is when iron and manganese problems would first be evident. At a TSI of 50, the turbidity of the water might be expected to exceed 1 NTU, and filtration of the raw water would become necessary. It is at a TSI of 50 that Arruda (1988) found that trihalomethane concentrations in the finished water exceed 100 mg/L in some Kansas treatment plants. Therefore, it is at this trophic state that extra measures or changes in the treatment process are necessary to control taste and odor without increasing the chlorine dose.

Recreation

Swimming/Primary Contact Recreation. Criteria to protect a contact recreation use may be associated with the occurrence (or appearance) of certain phenomena that affect certain types of recreation. For example, in general, swimmers will not be affected by the trophic state of the lake, but resulting changes in transparency or change in species may be important. Some States and countries have prohibitions on swimming based on the depth from which a body can be seen on the bottom. This consideration is based on the possibility of seeing a drowning child. New Zealand has a swimming

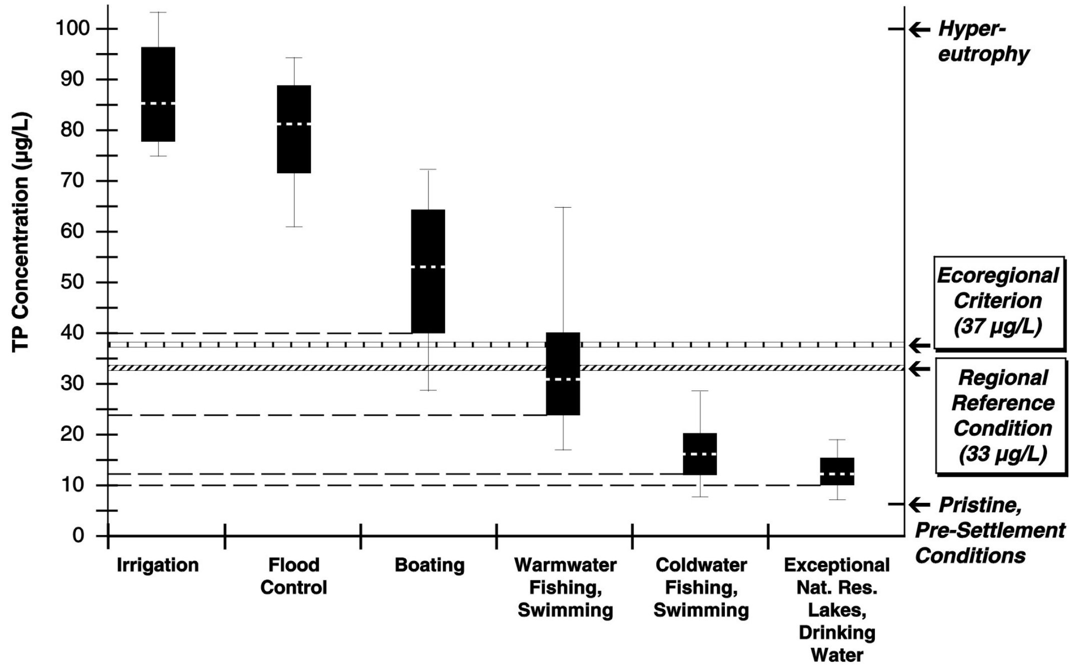

Figure 7.2. Development of TP criteria for select designated uses relative to the reference condition and ecoregional criterion for lakes of a specific size class.

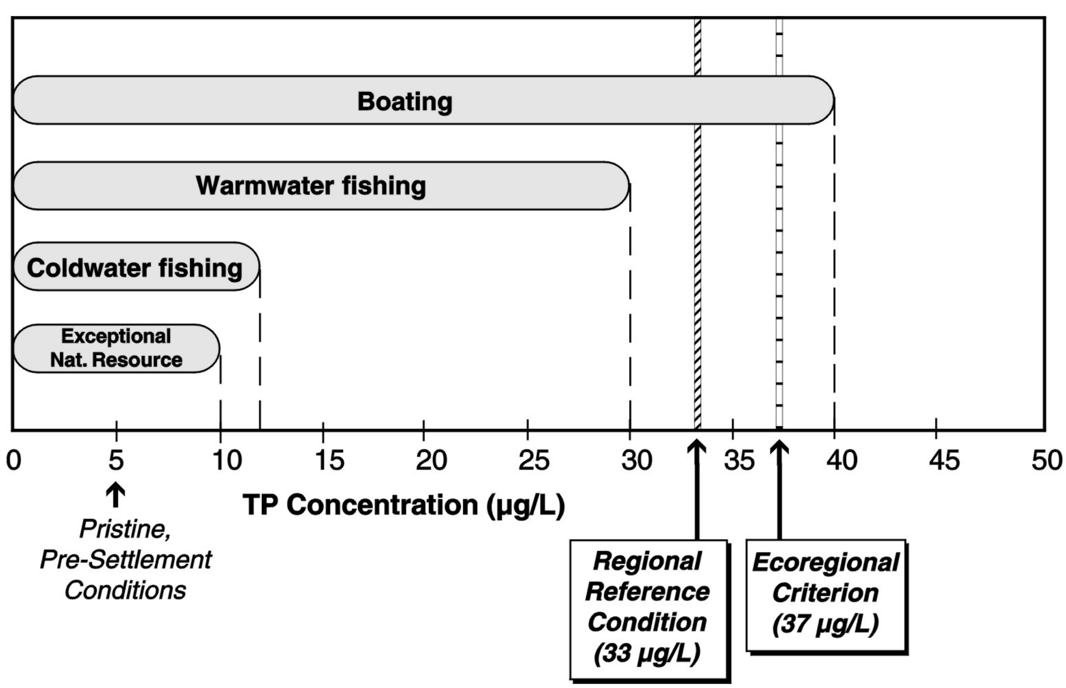

Figure 7.3. Simplified display of TP criteria for select designated uses in a specific size class.

United States Environmental Protection Agency
Office of Water 4304
EPA 822-B-00-009
December 2000

Ambient Water Quality Criteria Recommendations

Information Supporting the Development of State and Tribal Nutrient Criteria

Lakes and Reservoirs in Nutrient Ecoregion VII

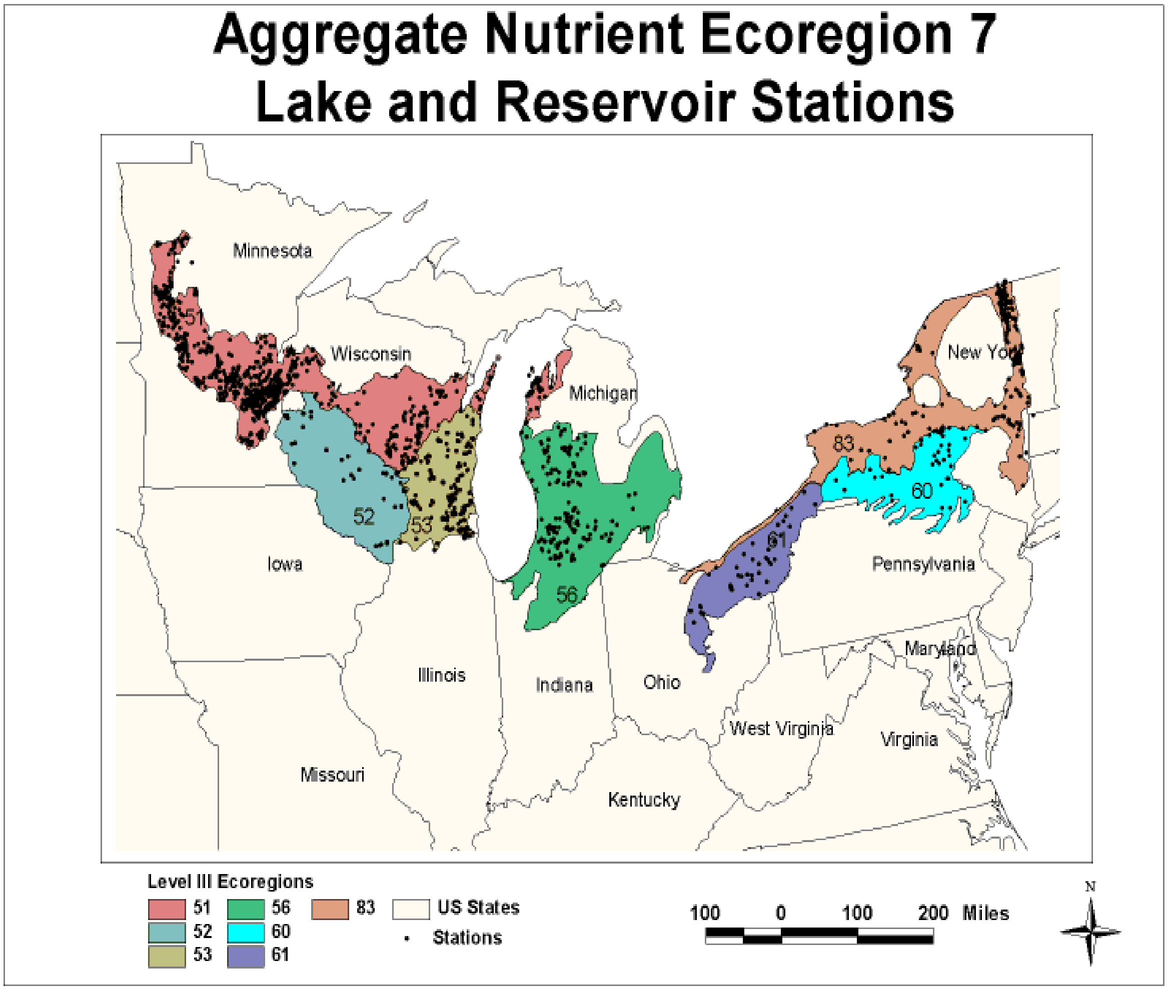

Figure 3 **Sampling locations within each level III ecoregion.**

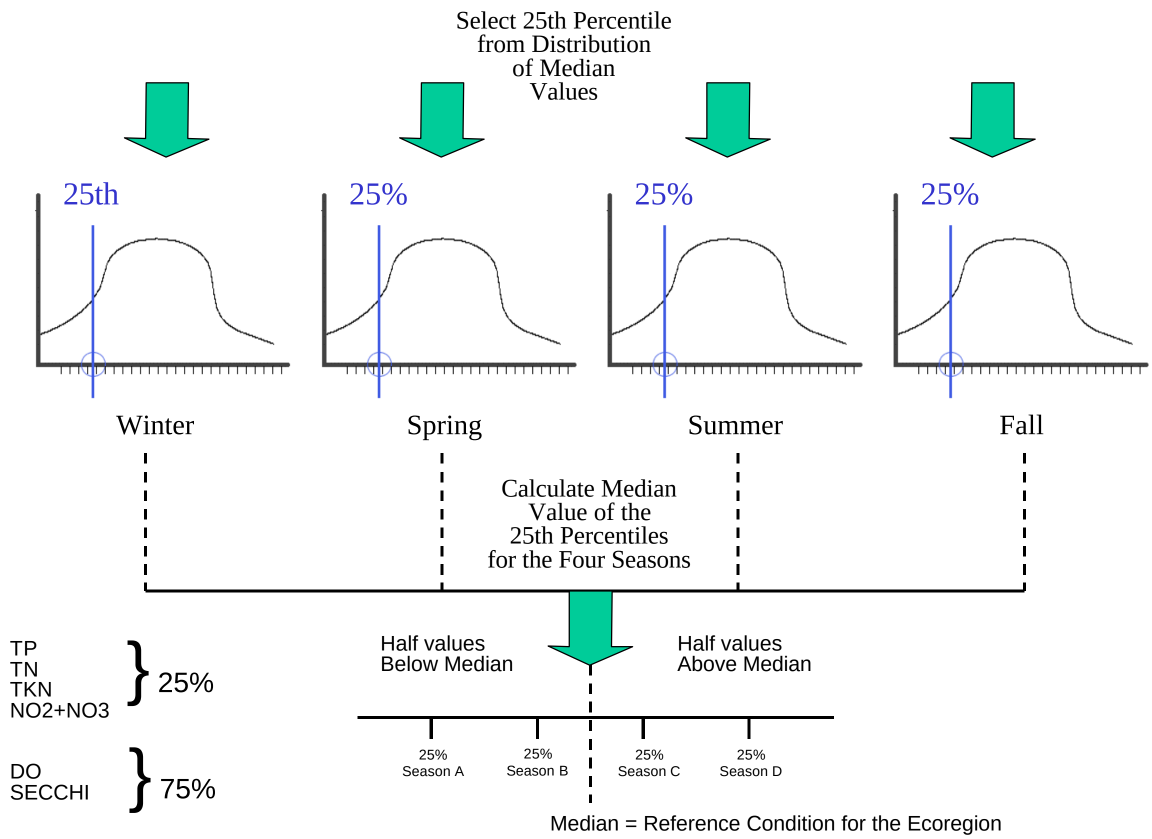

Figure 4b.Illustration of reference condition calculation.

! **RTAG expert review and consensus**
EPA recommends that when States and Tribes prepare their nutrient criteria, they obtain the expert review and consent of the RTAG.

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! **Downstream effects of criteria**
EPA encourages the RTAG to assess the potential effects of the proposed criteria on downstream water quality and uses.

In addition, EPA followed specific **QA/QC procedures** during data collection and analysis: All data were reviewed for duplications. All data are from ambient waters that were not located directly outside a permitted discharger. The following States indicated that their data were sampled and analyzed using either Standard methods or EPA approved methods: New York, Michigan, Minnesota, Ohio, Indiana, Illinois.

The following tables contain a summary of Aggregate and level III ecoregion values for TN, TP, water column chl *a*, and turbidity:

BASED ON 25th PERCENTILE ONLY

Nutrient Parameters	Aggregate Nutrient Ecoregion VII Reference Conditions
Total phosphorus (µg/L)	**14.75**
Total nitrogen (mg/L)	**0.66 reported (0.57 calculated)**
Chlorophyll *a* (µg/L) (Fluorometric method)	**2.63**
Secchi depth (meters)	**3.33**

For sub ecoregions, 51, 52, 53, 56, 60, 61, and 83, the ranges of nutrient parameter reference conditions are:

Table 3g.Reference conditions for level III ecoregion 83.

Parameter	No. of Lakes N ++	Reported values		25th Percentiles based on all seasons data for the Decade	Reference Lakes **
		Min	Max	P25* all seasons +	P75 all seasons
TKN (mg/L)	21	0.17	1.01	0.25	
NO2 + NO3 (mg/L)	54	0.01	1.05	0.01	
TN (mg/L) - calculated	NA	0.18	2.06	0.26	
TN (mg/L) - reported	22 S	0.42	0.44	0.42	
TP (*ug*/L)	83	4.0	107.5	11.25	
Secchi (meters)	100	0.5	8.35	4.75	
Chlorophyll *a* (*ug*/L) - F	66	0.73	64.34	2.84	
Chlorophyll *a* (*ug*/L) - S	--	--	--	--	
Chlorophyll *a* (*ug*/L) - T	–	–	–	--	