# Unreliability of US EPA-Proposed Florida Numeric Nutrient Criteria/Standards

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# Water Quality Standards for the State of Florida's Lakes and Flowing Waters
# January 2010 Fact Sheet — Summary

**"EPA has proposed water quality standards in the State of Florida that would set a series of numeric limits on the amount of phosphorus and nitrogen pollution, also known as "nutrient" that would be allowed in Florida's lakes, rivers, streams, springs and canals. This proposed action seeks to improve water quality, protect public health, aquatic life and the long term recreational uses of Florida's waters, which are a critical part of the State's economy. The proposed standards comply with the terms of a January 2009 EPA determination under the Clean Water Act that numeric nutrient standards are needed in Florida and an August 2009 consent decree between EPA and the Florida Wildlife Federation. "**

**http://www.epa.gov/waterscience/standards/rules/florida/factsheet.html**

# “Water Quality Standards (Numeric Nutrient Criteria) for Florida's Lakes and Flowing Waters a.k.a. FL Numeric Nutrient Criteria - Inland Waters”

## Abstract

“EPA is under a Consent Decree deadline to promulgate numeric nutrient water quality criteria (which are elements of water quality standards) for the State of Florida's lakes and flowing waters by October 15, 2010.”

http://yosemite.epa.gov/opei/RuleGate.nsf/6c93b95a7f1614c1852576b70060eb51/355215442d406485852576da0076d5cb!OpenDocument

# Issues

- Many Waterbodies in FL and throughout US Are Excessively Fertile
  - Excessive Growth of Planktonic Algae &/or Water Weeds
- US EPA Has Proposed Numeric Water Quality Criteria/Standards for Aquatic Plant Nutrients (N & P) for Waters of Florida
  - Based on Statistical Correlations between Total Concentrations in Water & Water Quality Impacts as Measured by Planktonic Algal Chlorophyll

# Issues

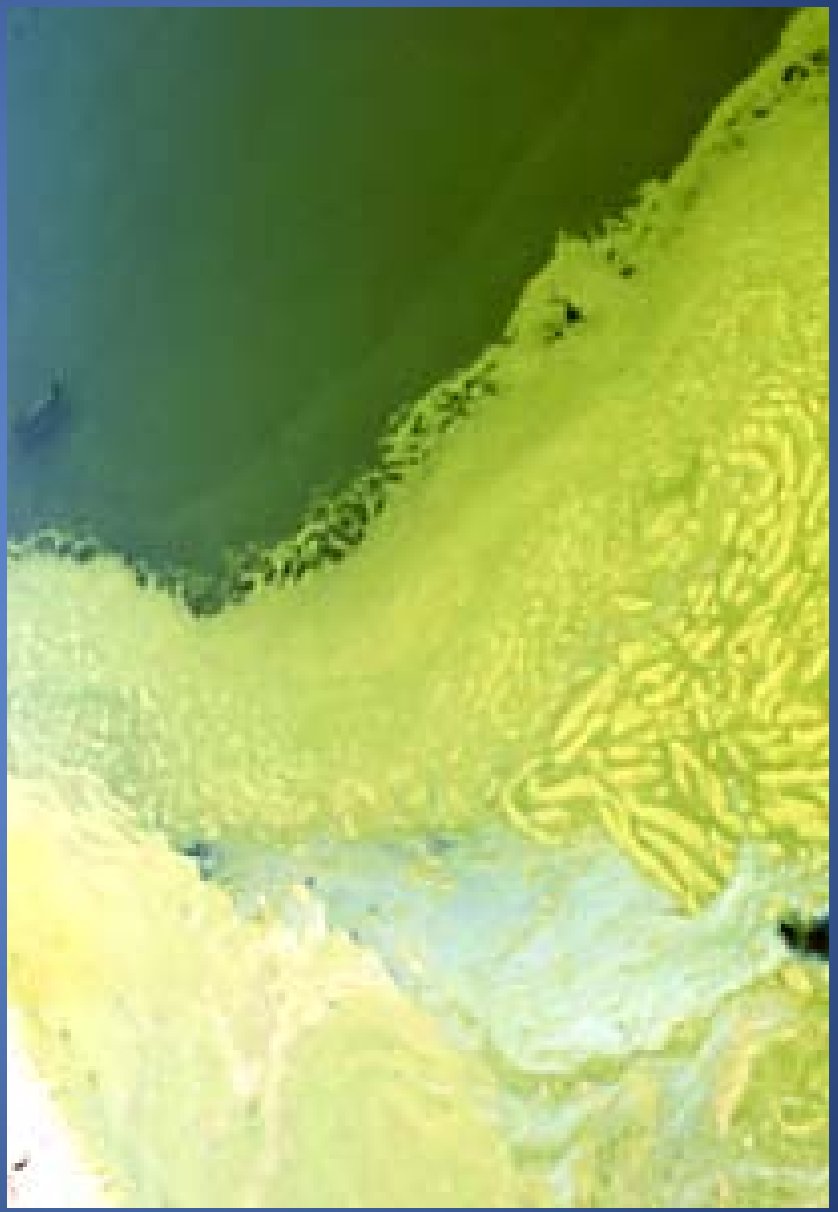
- US EPA Approach Unreliable
  - Not Based on Cause-and-Effect
  - Does Not Consider Aquatic Macrophytes
  - Will Lead to Significant Over-Regulation beyond That Needed to Control Excessive Fertilization Problems, for
    - Ag & Urban Stormwater Runoff
    - Wastewater Discharges
  - Ignores Substantial Literature on Technically Valid Approach for Assessing Role of Nutrient in Causing Nutrient-Related Water Quality Problems

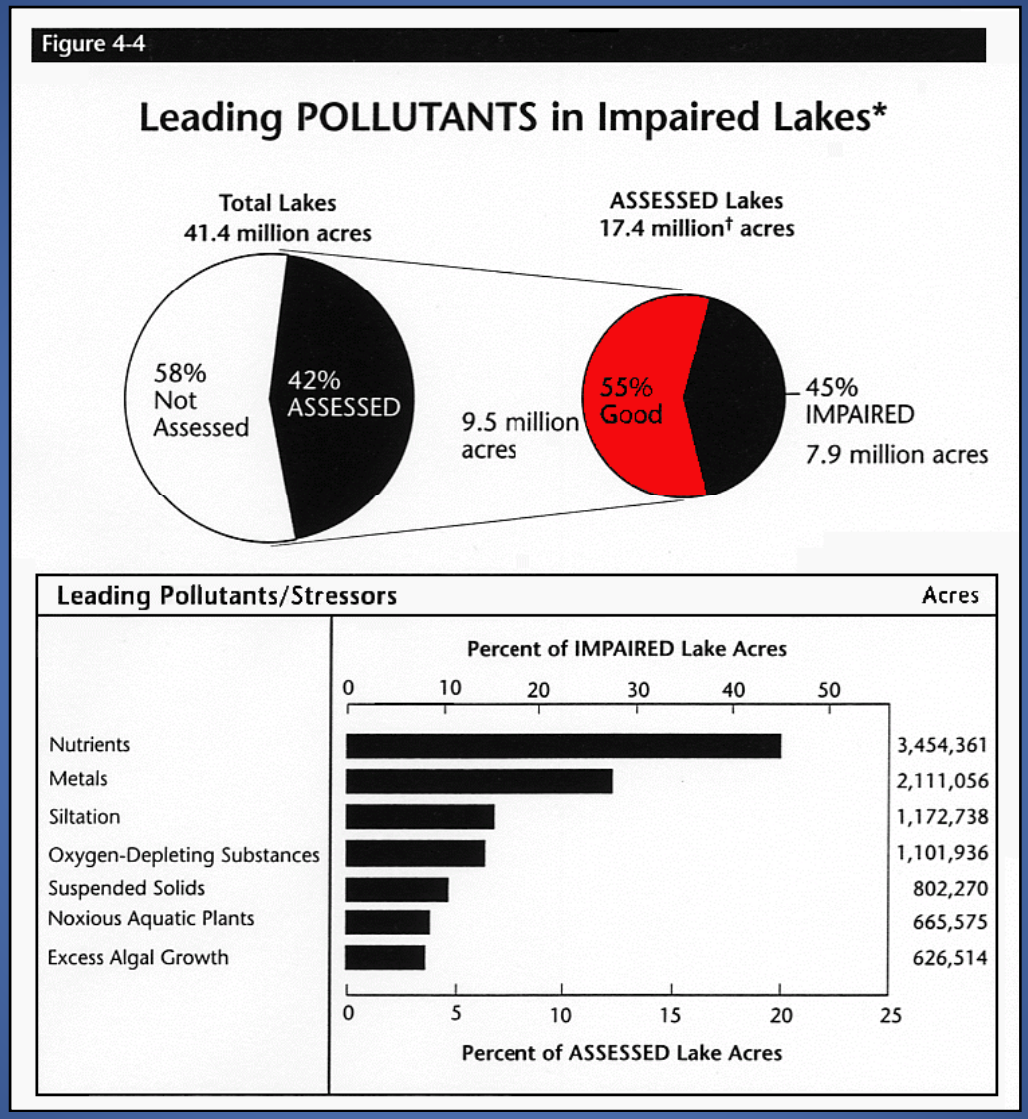
Few Algae:

High Water Quality

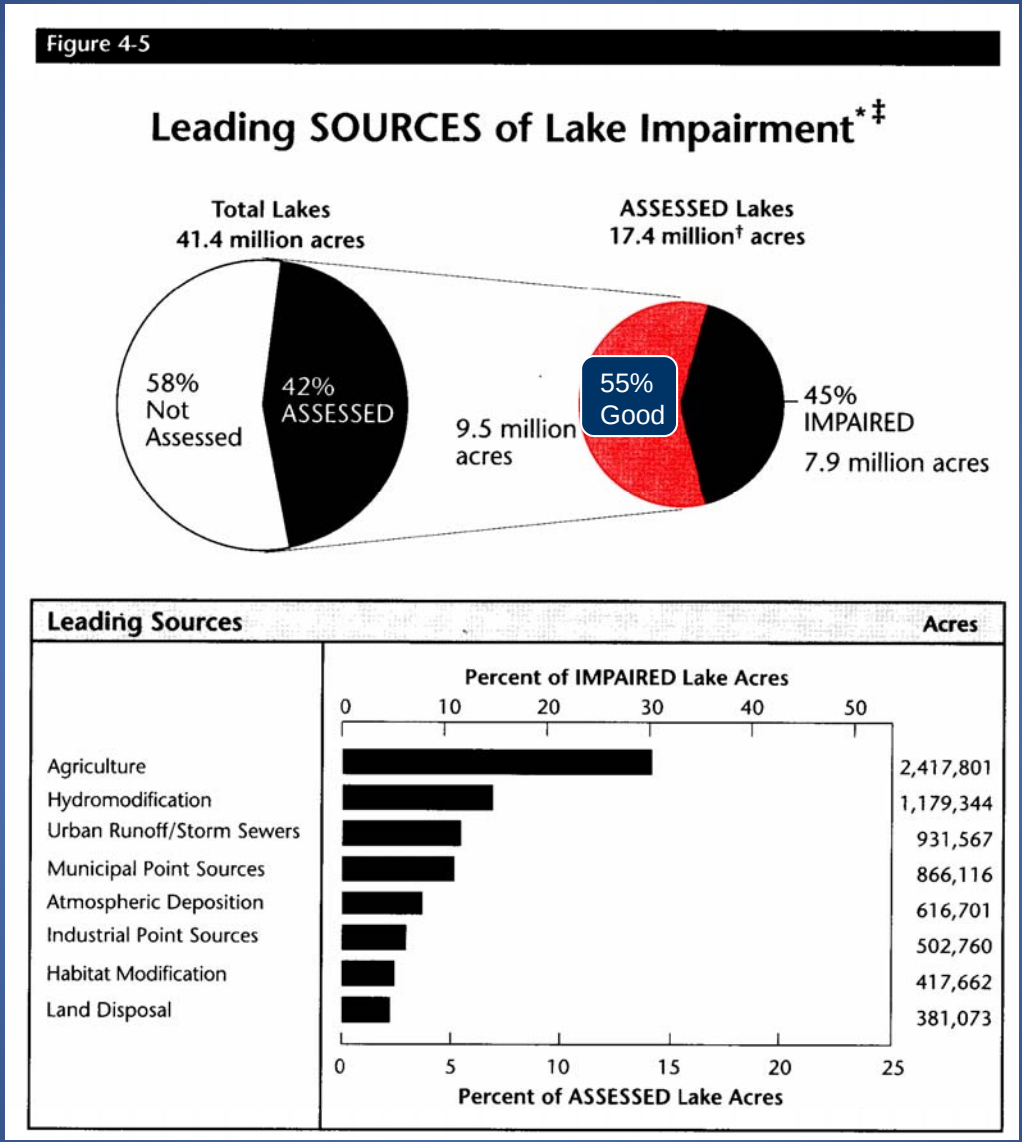
**Excessive Algae:**

**Poor Water Quality**






(from: US EPA, *National Water Quality Inventory – 1998 Report to Congress*, June 2000)




(from: US EPA, *National Water Quality Inventory – 1998 Report to Congress*, June 2000)

# Excessive Fertilization (Eutrophication) The Problem

- Excessive Growths of Aquatic Plants
  - Algae:  Plankton (Suspended) & Attached
  - Water Weeds:  Macrophytes, Floating & Attached
- Impacts
  - Impair Domestic Water Supplies
    - Tastes & Odors, Shortened Filter Runs
    - In Some Situations, Increase Trihalomethane Precursors (TOC)
      - THM's (Chloroform) Carcinogens
  - Cause Violations of Water Quality Standards
    - pH & Dissolved Oxygen
    - Diel Photosynthesis & Respiration

      1P $\rightarrow$ Algae $\rightarrow$ 276 O Consumed

      Gulf of Mexico Anoxia, Chesapeake Bay etc.

# Excessive Fertilization (Eutrophication) The Problem (cont'd)

- Impacts (cont'd)
  - Toxic Algae
    - Fish Kills (*Pfiesteria*)
    - Kill Livestock & Wildlife (Blue-Green Toxins)
    - Potential Toxicity in Drinking Water
  - Impairment of Recreation
    - Swimming, Boating, Fishing, Aesthetics (e.g., Odors, Scum)
  - Loss of Shallow Water Vegetation Habitat

    Algal Turbidity Reduces Light Penetration Needed for Emergent Plants
  - Impacts on Fisheries
    - Increase Amount of Fish Produced
    - Lead to Loss of Cold Water Fisheries if Resulting Oxygen Demand in Hypolimnion Is Sufficient to Deplete Oxygen
    - Can Lead to Increase in Less-Desirable, Rough Fish, e.g., Carp
- Excessive Fertilization Is One of Most Important Causes of Water Quality Impairment

# Problems with US EPA Approach

- Mechanical "Statistical Correlation" Approach
  - Can Readily Lead to Spurious Correlations with High "Correlation Coefficients" But No Ecological Validity
  - Typically Does Not Incorporate Quantitative Cause-and-Effect Couplings between Nutrient Load/Concentration and Water Quality Impact

Lee, G. F., and Jones-Lee, A., "Comments on 'Environmental Protection Agency 40 CFR Part 131 [EPA-HQ-OW-2009-0596; FRL-XXXX-X] [RIN 2040-AF11] Water Quality Standards for the State of Florida's Lakes and Flowing Waters,'" Submitted to US EPA Docket ID No. EPA-HQ-OW-2009-0596, by G. Fred Lee & Associates, El Macero, CA, April 7 (2010). http://www.gfredlee.com/Nutrients/FL-Nutrient-Std.pdf

# “Odds Are, It’s Wrong: Science Fails to Face the Shortcomings of Statistics”

- Siegfried, T., “Odds Are, It’s Wrong: Science Fails to Face the Shortcomings of Statistics,” Feature Article *Sciencenews* Vol. 177, no. 7, March 27 (2010).

  http://www.sciencenews.org/view/feature/id/57091/title/Odds_Are%2C_Its_Wrong

# US EPA Proposed Numeric Nutrient Criteria for Lakes

*(1) Proposed Numeric Nutrient Criteria for Lakes*

EPA is proposing the following numeric nutrient criteria and geochemical classifications for Florida's lakes classified as Class I or III waters under Florida law (Rule 62-302.400, F.A.C.):

| A | B | C | D | E | F |
|---|---|---|---|---|---|
| Long Term Average Lake Color and Alkalinity | Chlorophyll *a* [f] (µg/L) [a] | Baseline Criteria [b] | | Modified Criteria (within these bounds) [c] | |
| | | TP (mg/L) [a] | TN (mg/L) [a] | TP (mg/L) [a] | TN (mg/L) [a] |
| Colored Lakes > 40 PCU | 20 | 0.050 | 1.23 | 0.050-0.157 | 1.23-2.25 |
| Clear Lakes, Alkaline ≤ 40 PCU [d] and > 50 mg/L $CaCO_3$ [e] | 20 | 0.030 | 1.00 | 0.030-0.087 | 1.00-1.81 |
| Clear Lakes, Acidic ≤ 40 PCU [d] and ≤ 50 mg/L $CaCO_3$ [e] | 6 | 0.010 | 0.500 | 0.010-0.030 | 0.500-0.900 |

# US EPA-Proposed Statistical Approach for Developing National Nutrient Criteria
## ◂ Technical Review & Comment ▸

- Lee, G. F., and Jones-Lee, A., "Comments on 'US EPA "Empirical Approaches for Nutrient Criteria Derivation" Prepared by US EPA, Office of Water, Office of Science and Technology, Science Advisory Board Review, Draft August 17, 2009'," Report of G. Fred Lee & Associates, El Macero, CA, September 4 (2009). [http://www.gfredlee.com/Nutrients/EPA_Empirical_CritDevel.pdf]
- US EPA Science Advisory Board, Ecological Processes and Effects Committee Review of Proposed Nutrient Criteria Guidance

  [http://yosemite.epa.gov/sab/sabproduct.nsf/E09317EC14CB3F2B85257713004BED5F/$File/EPA-SAB-10-006-unsigned.pdf]
  - "EPA's Office of Water (OW) requested that the Science Advisory Board (SAB) review the Agency's draft guidance document titled *Empirical Approaches for Nutrient Criteria Derivation* ("Guidance"). The Guidance is one of a series of technical documents developed by OW to describe approaches and methods for developing numeric criteria for nutrients. The Guidance specifically focuses on empirical approaches for determining stressor-response relationships to derive numeric nutrient criteria. In response to the Agency's advisory request, the SAB Ecological Processes and Effects Committee, augmented with additional experts, met on September 9-11, 2009 to conduct a peer review of the Guidance."
  - Found Statistical Approach Not Valid – No Cause-and-Effect Coupling

# Some of the Findings of SAB Review of US EPA Nutrient Criteria

- "The Guidance needs to clearly indicate that the empirical stressor-response approach does not result in cause-effect relationships; it only indicates correlations that need to be explored further. For example, the words "cause-effect" should be removed from the title of Step two."

- "The Guidance should address partitioning the uncertainty among the various factors that are involved in the stressor-response relationship for the specific region/system of interest. Some variables may be irrelevant to the hypothesized model for that system."

- "The Guidance should better document the physical, chemical and biological variables comprising the relationships (e.g., habitat, spatial, and temporal) that define the aquatic system, and which may be important in modifying the relationship between nutrient concentrations and observed endpoints. These factors need to be well documented so that the uncertainty in the relationship between nutrient concentrations and measured endpoints can be reduced."

# Some of the Findings of SAB Review of US EPA Nutrient Criteria (cont'd)

- "EPA should discourage use of "biased" databases (i.e., that do not contain the range of data necessary to fully characterize a system of interest) to develop stressor-response relationships."
- "The Committee recommends predicting conditions that might result after implementing different nutrient criteria and testing these conditions on specific data-rich systems of interest."
- "The Committee recommends that EPA frame uncertainty according to the following key issues:
  - What are the goals of the decision makers (e.g., what are the designated uses and when are they impaired?), and what amount of certainty is required to make that decision?
  - Are the mechanisms of the cause-effect relationship understood and are they reflected in the types of measurements recommended?
  - Do the variables measured reflect the goals of the Clean Water Act? In the examples presented in Section 5 of the Guidance species richness or chlorophyll a are not clearly linked to the stated goals (fishable, swimmable waters, etc).
  - Does the analysis tool reflect a known cause-effect relationship and does it allow an understanding of the process?
  - What are the a priori criteria to be met by the data? This must be established to make it possible to tell when the data cannot support the decision making process."

# Control of Algal Growth
# Total P vs Algal-Available P

- US EPA Nutrient Criteria Based on Total P
  - Should Focus on Algal-Available P
    - Most Particulate P in Agricultural & Urban Stormwater Runoff Not Available to Support Algal Growth
    - Focus on Total P Would Require Ag & Others to Control Particulate P in Stormwater Runoff
      - Very Expensive
      - Not Justified for Protecting Algae-Related Water Quality

Available P ≈ Soluble OrthoP + 20% Particulate P

# Evaluating Allowable Nutrient Loads to Waterbody

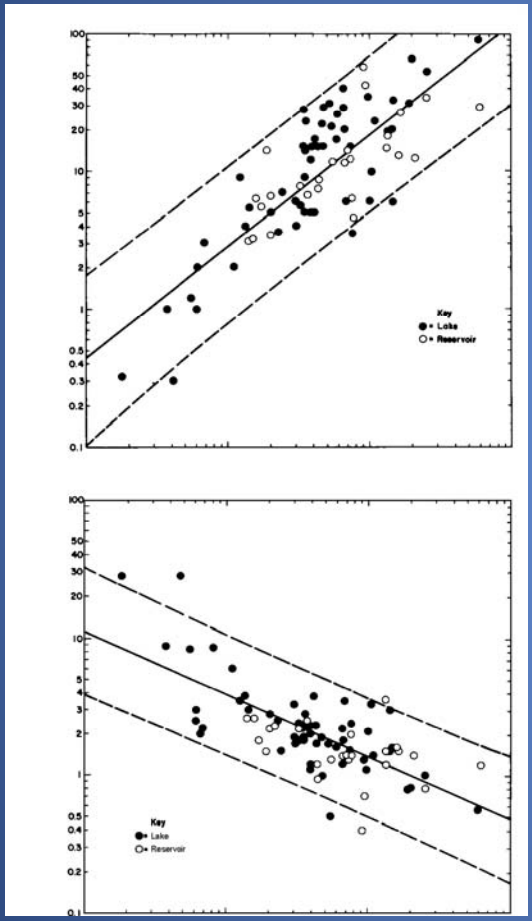
- Need Reliable Nutrient Load – Eutrophication Response Model TMDL Linkage
  - Empirical Statistical (e.g., Vollenweider—OECD)
    - Based on Large Database – 750 Waterbodies
  - Deterministic
    - Develop Differential Equations to Describe Primary Rate Processes That Relate Nutrient Concentrations/Loads to Algal Biomass

## Vollenweider—OECD Eutrophication Study

- One of Most Comprehensive, Quantitative Studies of Cause & Effect Relationships between
  - Nutrient Loading & Planktonic Algal Growth
- 5-yr, $50-million Study
- 200 Lakes & Reservoirs in North America, Europe, Japan, Australia
- Defined & Quantified Correlating Factors between Loading & Response
  - Waterbody Area
  - Waterbody Mean Depth
  - Waterbody Hydraulic Residence Time
- Subsequent Demonstration of Capability to Quantitatively Predict Water Quality Response to Altered P Loads

# Vollenweider—OECD Nutrient Load—Eutrophication Response Modeling

Mean Summer Chlorophyll a ($\mu g/L$)

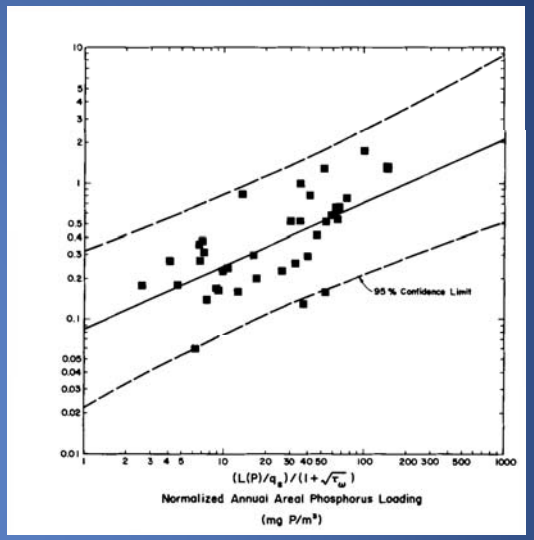



Mean Summer Secchi Depth (m)

Normalized P Loading

$(L(P)/q_s)/(1+\sqrt{T\omega})$

Hypolimnetic Oxygen Depletion Rate ($g\ O_2/m^2/d$)



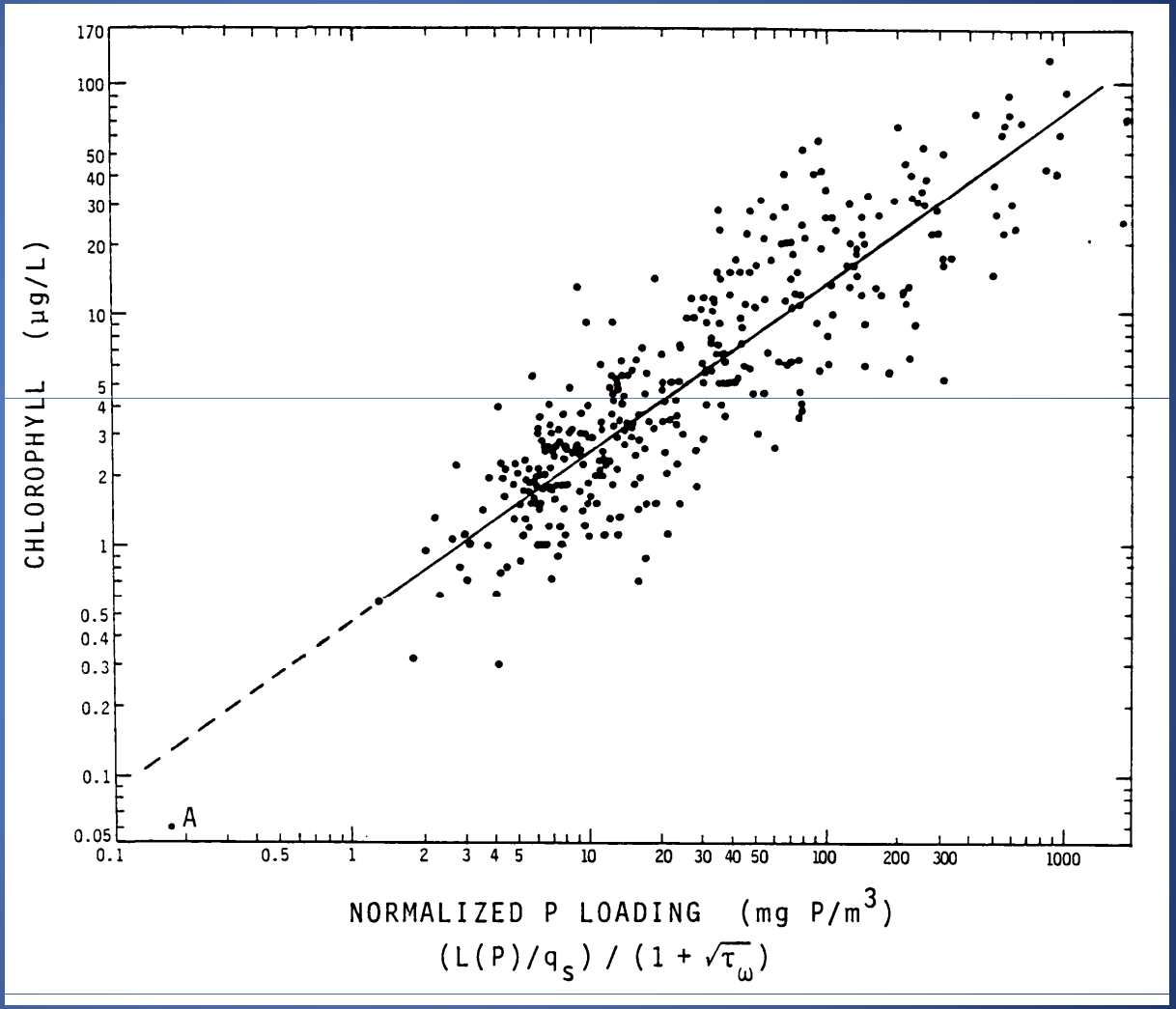

**KEY**

$L(P)$ = Areal Annual Phosphorus Load (mg $P/m^2/yr$)

$q_s$ = Mean Depth ÷ Hydraulic Residence Time = $\bar{z}/\tau_\omega$ (m/yr)

$\tau_\omega$ = Hydraulic Residence Time (yr)

**Updated P Loading – Chlorophyll Response Relationship from Data on Waterbodies Worldwide**



# Evaluating Allowable Nutrient Loads to Waterbody (cont'd)

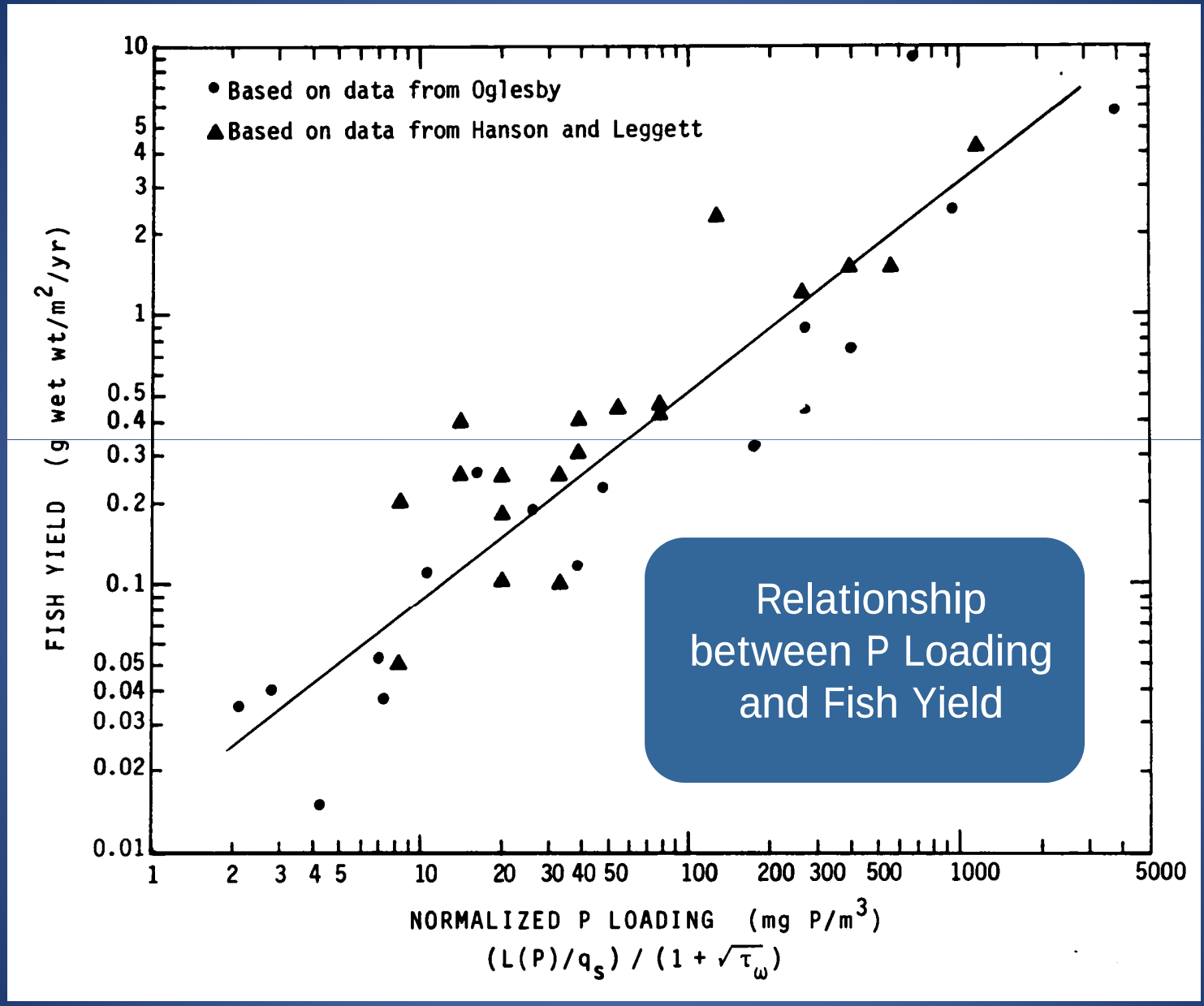
- Vollenweider – OECD Normalized Nutrient Load—Eutrophication Response Approach
  - Normalizing Factors:

    Waterbody Hydraulic Residence Time ($T_\omega$)

    Mean Depth ($\overline{Z}$)
  - Applies Directly to Lakes & Reservoirs & Planktonic Algae
  - Does Not Apply to Rivers & Streams
    - Need Site-Specific Studies
  - Does Not Apply to Water Weeds, Attached Algae
    - Need Site-Specific Studies

# Relationship between P Load & Fish Yield

- Follow-on Work Defined Relationship between P Load & Fish Yield
- Generally, Greater P Load $\Rightarrow$ Greater Fish Production
- Must Consider Impact of P Load Reductions on Fish Yield
- Lake Erie Situation




Relationship between P Loading and Fish Yield

# Guidance on Managing Excessive Fertilization of Waterbodies

- Lee, G. F. and Jones-Lee, A., "Developing Nutrient Criteria/TMDLs to Manage Excessive Fertilization of Waterbodies," Proceedings Water Environment Federation, TMDL 2002 Conference, Phoenix, AZ, November (2002).
- http://www.gfredlee.com/Nutrients/WEFN-Criteria.pdf

# Recommended Approach for Developing Nutrient Criteria (cont'd)

- Evaluate Nutrient Loads/Concentrations to Achieve Desired Nutrient-Related Water Quality
  - If Lake or Reservoir Water Quality Problem Is Caused by Excessive Planktonic Algae
    - Determine If Waterbody Fits Vollenweider—OECD Model Results
  - If Waterbody Does Not Fit OECD Model Results **OR** If Waterbody Is Stream or River
    - Conduct Site-Specific Study to Establish Nutrient Loads & Eutrophication-Related Water Quality Response
      - Will Likely Require Several Iterations to Develop Site-Specific Load—Response Relationship for Waterbody

# Recommended Approach for Developing Site-Specific Nutrient Criteria & Nutrient TMDL Target

- **Develop Problem Statement**
  - Establish Desired Water Quality Goal for Nutrient Control
  - TMDL Target – Relate Desired Water Quality Characteristics to Nutrient Load
  - Identify & Quantify Sources of Available Nutrients
  - Establish Linkage between Nutrient Load & Eutrophication Response

# Issues That Need Consideration in Developing Appropriate Nutrient Control Program

- What Is the Nutrient-Caused Water Quality Problem(s)?
- When Does the Water Quality Problem Occur?
  - Summer?  Fall?
- Which Nutrient Loads Cause/Contribute to Excessive Fertilization of Waterbody (i.e., Cause Water Quality – Use– Impairment)?
  - Annual Load; Seasonal Loads
- What Is the Hydraulic Residence Time (Filling Time) of Waterbody?
- When & Where Do the Nutrients That Cause Water Quality Problems, Enter the Waterbody?
- How Will the Magnitude of the Nutrient–Caused Water Quality Problems Change with Given Change in Nutrient Load?
- What Will Be Cost of Nutrient Control to Achieve Desired Water Quality?
  - Who Will Pay These Costs?

# Nutrient Water Quality Criteria

- Should Be Based on Site-Specific Evaluation for the Particular Waterbody
  - Nutrient TMDL Target (Goal) Should Be Based on Waterbody-Specific Evaluation of Desired Nutrient-Related Water Quality
    - Translate Desired Water Quality into Appropriate Nutrient Concentrations/Loads
  - Similar Approach Used to Establish Nutrient Water Quality Criteria & TMDL Target

# Recommended Approach for Developing Nutrient Criteria

- Establish Desired Nutrient-Related Water Quality through Public Process Conducted by Regulatory Agency
- Issues:
  - No Violation of Average/Worst-Case Diel DO or pH
  - Minimize Adverse Impacts of Nutrients—Algae on Domestic Water Supplies
    - Tastes, Odors, Filter Runs
  - Water Clarity – Secchi Depth
    - Water Depth at Which the “Sediment” Can Be Seen
  - Water Greenness – Planktonic Algal Chlorophyll
  - Waterbody Area Covered by Excessive Water Weeds
  - Desired Fish Production

# Recommended Approach for Developing Site-Specific Nutrient Criteria & Nutrient TMDL Target

- Phase I
  - Implement Nutrient Control Program
  - Monitor Response for 3 to 5 Years
- Phase II
  - Adjust Nutrient Loads to Achieve Desired Water Quality
- Evolve to Appropriate Nutrient Criteria for Waterbody &/or
- Nutrient Control Program to Satisfy TMDL

# Overall

- US EPA Mechanical, Statistics-Based Approach for Nutrient Criteria/Standards:
  - Not Technically Valid
  - Should Not Be Adopted
- Need to Develop Framework to Develop & Implement Control Programs for Excessive Fertilization Based on
  - Site-Specific Definition of Nutrient Load—Eutrophication-Related Water Quality Characteristics
  - Technically Reliable Load—Response Framework e.g., Vollenweider—OECD Eutrophication Modeling Approach

# Further Information

## Consult Website of
## Drs. G. Fred Lee and Anne Jones-Lee

## http://www.gfredlee.com

Excessive Fertilization Section:
http://www.gfredlee.com/pexfert2.htm