Comments on
"California Environmental Quality Act Scoping Meeting
Statewide Policy for Nutrient Control in Inland Surface Waters in California"

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"Comment Letter – Statewide Nutrient Policy"

In response to the SWRCB request for comments on the "California Environmental Quality Act Scoping of the Statewide Policy for Nutrient Control in Inland Surface Waters in California," we submit the following comments.

The SWRCB lists in its Nutrient Policy Scoping Document [http://www.swrcb.ca.gov/plans_policies/docs/nutrients/scpng_doc.pdf] the following potential objectives of the CEQA review:

"Potential Objectives, Implementation and Monitoring Subject to Scoping Consideration
Objective Alternatives for State Water Board Action
1. No action.
2. Adopt U.S. EPA's recommended nutrient criteria using the Ecoregion Approach.
3. Adopt a statewide Nutrient Policy with narrative objectives, using the freshwater CA NNE Approach as a numeric translator to set nutrient limits.
Implementation Alternatives for State Water Board Action
1. No action.
2. Adopt implementation methods under U.S. EPA's Ecoregion Approach.
3. Adopt Freshwater CA NNE implementation methods.
Monitoring Alternatives for State Water Board Action
1. No action.
2. Establish statewide requirements for nutrient monitoring based on U.S. EPA's Ecoregional Approach
3. Establish statewide requirements for nutrient monitoring based on the Freshwater CA NNE.
4. Provide narrative guidance.

Conclusion Regarding Proposed Approach

None of the proposed Potential Objectives, Implementation Alternatives, or Monitoring Alternatives will lead to technically valid, cost-effective approaches for managing the excessive fertilization of California's waterbodies. The Freshwater CA-NNE could become a viable approach for developing nutrient criteria. However there are many questions about how the marine NNE will be implemented, especially with respect to trying to develop nutrient loads that address subtle impacts on a waterbody's water quality. The same questions will be raised with the application of this approach to the state's freshwaters. The first step to developing reliable, technically sound nutrient criteria should be the defining of nutrient loads for waterbodies that maintain desired well-recognized, traditional nutrient-related water quality characteristics as measured by planktonic algal biomass, water clarity, impaired recreation, domestic water supply-related tastes and odors, and depressed DO. Background information on this conclusion is provided in the "Summary of Experience" appended to these comments.

Recommended Approach

It is our recommendation that the SWRCB establish a nutrient policy that would require site-specific evaluation of existing nutrient-related water quality/impairment of use (e.g., excessive algal biomass or water weeds, tastes and odors in water supply, depressed DO). If the nutrient-related water quality is deemed to be impaired, the loads of available forms of nutrients sustaining the adverse conditions as well as reductions in the loads needed to achieve the desired nutrient-related water quality need to be determined. This assessment must be based on a verifiable cause-and-effect coupling between nutrient load and water quality response. Based on the desired nutrient load, site-specific nutrient criteria/standards can be developed for the waterbody.

Summary of Experience in Establishing Nutrient Water Quality Criteria/Standards

Dr. G. Fred Lee has been active in investigating the impacts of nutrients on water quality since the early 1960s; Dr. Anne Jones-Lee has worked with Dr. Lee on these issues since the mid-1970s. Additional information on their work in this area is appended to these comments; many of their papers and reports on the sources, water quality significance, assessment, regulation, and control of aquatic plant nutrients are available on their website [www.gfredlee.com] in the Excessive Fertilization/Eutrophication section at http://www.gfredlee.com/pexfert2.htm.

In 2002 Lee and Jones-Lee published a paper discussing the development of technically valid nutrient criteria/standards:

> 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

That paper discusses technical issues that need to be evaluated to develop appropriate nutrient loads to a waterbody to achieve the desired nutrient-related water quality. Excerpts from that paper follow.

"*In developing the appropriate nutrient criteria, it is suggested that the TMDL development approach is an appropriate approach to follow. This approach involves the following steps:*

- *Developing a problem statement of the excessive fertilization situation of concern.*
- *Establishing the goal of nutrient control (i.e., the desired eutrophication-related water quality).*
- *Determining nutrient sources, focusing on available forms.*
- *Establishing linkage between nutrient loads and eutrophication response (modeling).*
- *Initiating a Phase I nutrient control implementation plan to control the nutrients to the level needed to achieve the desired water quality.*
- *Monitoring the waterbody for three to five years after nutrient control is implemented to determine whether the desired water quality is being achieved.*

- *If not, initiating a Phase II where, through the monitoring results, the load-response model is improved and thereby able to more reliably predict the nutrient loads that are appropriate for the desired water quality.*

This approach is an iterative approach, where, over a period of at least five to possibly 15 years, through two or more consecutive phases, it will be possible to achieve the desired water quality and thereby establish the nutrient loads which can be translated to in-waterbody concentrations and, therefore, the nutrient criteria for the waterbody. Information on several of these components is discussed below."

"ISSUES THAT NEED TO BE CONSIDERED IN DEVELOPING APPROPRIATE NUTRIENT CONTROL PROGRAMS

There are a number of key issues that need to be considered/evaluated in formulating nutrient control programs, the most important of which is the nutrient load-eutrophication response relationship for the waterbody(ies) of concern. Each waterbody has its own water quality-related load-response relationship that needs to be evaluated. As discussed herein, the notion that this evaluation should be restricted to just the US EPA's "ecoregion" approach, where waterbodies of a particular type, such as a lake, river, stream, etc., in an ecoregion can all have the same nutrient criteria, is fundamentally flawed since it ignores the vast amount of work that was done in the 1960s and 1970s in developing technically valid nutrient control programs for various types of waterbodies located in various areas.

The primary issue of concern is the identification of the nutrient loads to a particular waterbody that cause or contribute to excessive fertilization of the waterbody -- i.e., cause water quality use impairment. Associated with this are the issues of when the water quality problems occur (in the summer, fall, winter, etc.), how they are manifested (planktonic algae, attached algae, macrophytes), what the desired eutrophication-related water quality is for the waterbody, what the hydraulic residence time (filling time) of the waterbody is and when the nutrients enter the waterbody that cause the water quality problems. The relationship among these various factors has recently been reviewed by Jones-Lee and Lee (2001). The ultimate goal of managing eutrophication-related water quality is to assess how the magnitude of the nutrient-caused water quality problem changes with a change in nutrient loads. This requires that an assessment of the cost of nutrient control to achieve desired water quality be developed."

"Evaluating Allowable Nutrient Loads to Waterbodies
To establish the allowable nutrient loads for a waterbody, it is necessary to model the nutrient load-eutrophication response relationships for the waterbody. There are basically two types of models:

- *An empirical, statistical model, such as the Vollenweider-OECD Eutrophication model discussed herein, which involves a large database on how nutrient concentrations or loads relate to the nutrient-related water quality characteristics of the waterbody.*
- *A deterministic model, in which differential equations are used to describe the primary rate processes that relate nutrient concentrations/loads to algal biomass.*

The deterministic modeling approach, while able to be tuned to relate nutrient loads to eutrophication response, may have limited predictive capability. Because of the number of *equations used, there is no unique solution to the model, and therefore, tuning the model may not properly represent the conditions that would be important in predicting eutrophication response (such as planktonic algae) under altered nutrient loads.*

Desired Nutrient-Related Water Quality

The first step in developing appropriate nutrient water quality criteria is to establish the desired nutrient-related water quality for the waterbody (ies). This should be done through a public process conducted by the regulatory agency. Such issues as no violation of the average/worst-case diel DO and pH, minimizing adverse impacts of nutrients on algal-caused domestic water supply raw water quality (i.e., controlling tastes and odors, filter runs, etc.) and water clarity/Secchi depth are important eutrophication-related water quality parameters for those waterbodies where the excessive fertilization is manifested as planktonic algae. One of the frequently used indicators of eutrophication-related water quality is water clarity. Water clarity is often measured by a Secchi depth. The Secchi depth is based on the visual observation of the depth at which a 20 cm circular disk painted with black and white quadrants can be observed from the surface. With respect to water clarity, the issue is basically one of the depth of the waterbody at which the bottom sediments can still be seen from the surface. Waterbodies with high degrees of clarity (i.e., the bottom can be seen even at depths of 20 or more feet) are ones with low planktonic algal content. For more eutrophic waterbodies, typically the sediments can only be seen at a depth of a few feet.

"Impact on Fisheries

Fertilization of waterbodies improves fish production in terms of total biomass; however, as Lee and Jones (1991)

> Lee, G. F. and Jones, R. A., "Effects of Eutrophication on Fisheries," *Reviews in Aquatic Sciences,* **5**:287-305, CRC Press, Boca Raton, FL (1991).
> http://www.gfredlee.com/Nutrients/fisheu.html

discuss, that nutrient reduction can be adverse to production of desirable forms of fish, especially at high fertilization levels. In waterbodies that stratify, with a cold hypolimnion (bottom waters), oxygen demand created by the growth of algae in the surface waters which die and settle into the hypolimnion can be sufficient to deplete the oxygen. This is a characteristic of highly eutrophic waterbodies. This, in turn, means that, in temperate climates, the coldwater fish (such as the salmonids, trout, etc.) that normally inhabit the hypolimnion cannot survive because of a lack of oxygen. Further, with respect to the increased production in highly eutrophic waterbodies, the populations of rough fish, such as carp, which can tolerate lower dissolved oxygen levels, often dominate the increased production.

Nutrient management programs should include an assessment of the impact of nutrient control on desirable fish populations.

Impact of Nutrients on Sediment Quality and DO

It has been well-documented since the 1970s that aquatic sediments can exert a very large, essentially immediate, chemical-based oxygen demand when suspended in the water column. This issue and its implications are discussed in the following paper, which is an updated summary of the approximately $1-million studies that the authors conducted for the US Army Corps of Engineers on the development and evaluation of dredged sediment disposal criteria.

Lee, G. F. and Jones-Lee, A., "Water Quality Aspects of Dredging and Dredged Sediment Disposal," IN: Handbook of Dredging Engineering, Second Edition, McGraw Hill, pp. 14-1 to 14-42 (2000). http://www.gfredlee.com/Sediment/dredging.html

This oxygen demand is the result of the accumulation of ferrous iron, and sulfide species in the sediment. Aquatic sediments also can accumulate high concentrations of ammonia and hydrogen sulfide which themselves are highly toxic to aquatic like. Even though these issues are well-known in the technical literature, they are not adequately considered by the SWRCB staff and Board in developing so-called sediment quality criteria/objectives. Ignoring these issues means that some of the most important impacts of aquatic sediment on a waterbody's water quality are not being addressed in the current SWRCB sediment quality objectives. These issues have been brought to the attention of the SWRCB in the comments cited below.

Lee, G. F., and Jones-Lee, A., "Comments on the SWRCB Staff's Proposed Approach for Developing Sediment Quality Objectives for Enclosed Bays and Estuaries of California," Submitted to State Water Resources Control Board, Sacramento, CA, by G. Fred Lee & Associates, El Macero, CA, November 30 (2007). http://www.gfredlee.com/Sediment/SedQualObj11-07.pdf

Lee, G. F., and Jones-Lee, A., "Comments on 'Draft Staff Report Substitute Environmental Document Proposed Amendments to the Water Quality Control Plan for Enclosed Bays and Estuaries – Part 1 Sediment Quality for the Protection of Fish and Wildlife' Report of State Water Resources Control Board Division of Water Quality, January 28, 2011," Submitted to State Water Resources Control Board, Report of G. Fred Lee & Associates, El Macero, CA, March 14 (2011). [216 kb] http://www.gfredlee.com/Sediment/SedQualDraftSubCom.pdf

Lee, G. F., and Jones-Lee, A., "Conclusions & Recommendations – Developing Updated Sediment Quality Objectives," PowerPoint Slides Summary of Lee, G. F., and Jones-Lee, A., "Comments on 'Draft Staff Report Substitute Environmental Document Proposed Amendments to the Water Quality Control Plan for Enclosed Bays and Estuaries – Part 1 Sediment Quality for the Protection of Fish and Wildlife' Report of State Water Resources Control Board Division of Water Quality, January 28, 2011," Submitted to State Water Resources Control Board, Report of G. Fred Lee & Associates, El Macero, CA, March 14 (2011). http://www.gfredlee.com/Sediment/SedQualDraftSubPpt.pdf

Lee, G. F., and Jones-Lee, A., "Comments on 'Draft Staff Report, Water Quality Control Plan for Enclosed Bays and Estuaries – Part 1. Sediment Quality Developed by State Water Resources Control Board, California Environmental Protection Agency July 18, 2008'" and Answers to SWRCB Staff Responses to Comments on September 2007 Proposed SQO Development Approach. Submitted to State Water Resources Control Board, Sacramento, CA. Report of G. Fred Lee & Associates, El Macero, CA, September 5 (2008). http://www.gfredlee.com/Sediment/SQOCommentsAnswers.pdf

As discussed in our writings including those cited below, the high inorganic oxygen demand of many aquatic sediments can cause significant DO depletion in the water column when the sediments are suspended into the water column such as occurs during storms and high flows and by the activity of organisms such as carp. That DO depletion can kill or impair fish and other aquatic organisms.

> Lee, G. F. and Jones-Lee, A., "Role of Aquatic Plant Nutrients in Causing Sediment Oxygen Demand Part I – Origin of Rapid Sediment Oxygen Demand," Report of G. Fred Lee & Associates, El Macero, CA, May (2007). http://www.gfredlee.com/Sediment/NutrientSOD1RapidOD.pdf
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> Lee, G. F., and Jones-Lee, A., "Role of Aquatic Plant Nutrients in Causing Sediment Oxygen Demand Part II – Sediment Oxygen Demand," Report of G. Fred Lee & Associates, El Macero, CA, June (2007). http://www.gfredlee.com/Sediment/NutrientSOD2SOD.pdf
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> Lee, G. F., and Jones-Lee, A., "Role of Aquatic Plant Nutrients in Causing Sediment Oxygen Demand Part III – Sediment Toxicity," Report of G. Fred Lee & Associates, El Macero, CA, June (2007). http://www.gfredlee.com/Sediment/NutrientSOD3Tox.pdf

The origin of the high inorganic chemical-based oxygen demand in aquatic sediments is algae and other aquatic plants that develop in the water column, die, and settle to the sediments. There the bacterial decomposition of the organic matter in the algae exerts an oxygen demand that leads to the chemical reduction of ferric iron and sulfate to ferrous iron and sulfide. These reactions cause aquatic sediments to become anaerobic/anoxic just below the surface of the sediments. The oxygen demand in aquatic sediments contributes to the depletion of DO in the hypolimnion of stratified waterbodies through diffusion of the oxygen demand constituents into the water column.

> Lee, G. F., "Factors Affecting the Transfer of Materials between Water and Sediments," Published as Literature Review No. 1, Eutrophication Information Program, Water Resources Center, University of Wisconsin, Madison, July 1970. http://www.gfredlee.com/Sediment/NewFactors-Affecting-Paper-Revised.pdf

In evaluating the impacts of nutrients added to a waterbody on the water quality there is need to consider the role of aquatic plants in causing sediment oxygen demand. Evaluation of these situations requires detailed sampling of the waterbody during storms and other conditions that stir the sediments into the water column.

San Joaquin River Watershed and Delta Nutrient Water Quality Issues

Beginning in the late-1980s Lee and Jones-Lee became involved in evaluating the impact of aquatic plant nutrients on water quality in the San Joaquin River and Delta. They developed several papers and reports on their own, and others' studies of these issues, which are listed in the appendix to these comments and are available on their website (www.gfredlee.com) in the Watershed Studies San Joaquin River Watershed Studies Delta subsection at http://www.gfredlee.com/psjriv2.htm. As discussed in those papers, the waters of the San Joaquin River and Delta are excessively fertile due to the discharges of N and P compounds primarily from agricultural runoff/discharges. Those nutrients cause excessive growths of planktonic algae and, in some areas, floating and attached algae and macrophytes, that lead to low DO concentrations in the SJR Deep Water Ship Channel and south Delta channels, tastes and odors in domestic water supplies, the development of bluegreen algae some of which are toxic to animals, alterations in aquatic life habitat that adversely impact the development of desirable forms of aquatic life, and significant impairment of recreational use of these waterbodies.

In 2008 on behalf of the California Water Environmental Water Modeling Forum, Lee coordinated a Delta nutrient modeling workshop that included a review of the current Delta nutrient water quality problems. Information on that workshop, including the PowerPoint slides used by the presenters, is available at:

Lee, G. F., and Jones-Lee, A., "Synopsis of CWEMF Delta Nutrient Water Quality Modeling Workshop – March 25, 2008, Sacramento, CA," Report of G. Fred Lee & Associates, El Macero, CA, May 15 (2008). http://www.gfredlee.com/SJR-Delta/CWEMF_WS_synopsis.pdf

"Overview of Delta Nutrient Water Quality Problems: Nutrient Load – Water Quality Impact Modeling," Agenda for Technical Workshop sponsored by California Water and Environmental Modeling Forum (CWEMF), Scheduled for March 25, 2008 in Sacramento, CA (2008).
http://www.gfredlee.com/SJR-Delta/CWEMF_Workshop_Agenda.pdf

Lee, G. F., and Jones-Lee, A., "Overview—Sacramento/San Joaquin Delta Water Quality," Presented at CA/NV AWWA Fall Conference, Sacramento, CA, PowerPoint Slides, G. Fred Lee & Associates, El Macero, CA, October (2007).
http://www.gfredlee.com/SJR-Delta/DeltaWQCANVAWWAOct07.pdf

Lee, G. F., and Jones-Lee, A., "Delta Nutrient-Related Water Quality Problems," PowerPoint Slides Presented at CALFED Science Conference, Sacramento, CA, October 24 (2008).
http://www.gfredlee.com/SJR-Delta/CALFED_SciConf10-08.pdf

Lee, G. F., and Jones-Lee, A., "Issues in Controlling the Residual Oxygen Demand in the SJR DWSC That Leads to DO WQO Violations," Report of G. Fred Lee & Associates, El Macero, CA, November 3, 2010; updated February 6 (2011).
http://www.gfredlee.com/SJR-Delta/Residual-Ox-Demand-DWSC.pdf

Lee, G. F., and Jones-Lee, A., "Background Information on SJR Upstream Oxygen Demand Control Issues," Prepared for San Joaquin River Technical Work Group, Report of G. Fred Lee & Associates, El Macero, CA, July 11 (2010).
http://www.gfredlee.com/SJR-Delta/Bkgrnd-SJR-DO.pdf

Lee, G. F., and Jones-Lee, A., "Nutrient-Related Water Quality Concerns in the Sacramento and San Joaquin Rivers and Delta," Report of G. Fred Lee & Associates, El Macero, CA, September (2006). http://www.gfredlee.com/SJR-Delta/NutrWQDelta.pdf

Lee. G. F., and Jones-Lee, A., "Synthesis and Discussion of Findings on the Causes and Factors Influencing Low DO in the San Joaquin River Deep Water Ship Channel near Stockton, CA: Including 2002 Data," Report Submitted to SJR DO TMDL Steering Committee/Technical Advisory Committee and CALFED Bay-Delta Program, G. Fred Lee & Associates, El Macero, CA, March (2003). http://www.gfredlee.com/SJR-Delta/SynthesisRpt3-21-03.pdf

Lee, G. F., "Comments on Developing Nutrient Criteria for SJR Delta," email to Christine Joab, Central Valley Regional Water Quality Control Board, Rancho Cordova, CA, March 29 (2011).
http://www.gfredlee.com/SJR-Delta/Delta-Nutr-Criteria-Com.pdf

Lee and Jones-Lee's writings on these issues include recommendations on how to develop nutrient control programs to evaluate and begin to control the excessive fertilization of these waters. The SWRCB scoping of nutrient criteria should review and address each of the types of situations that are occurring in these waters as discussed in our papers on these issues. Some of the key issues include focusing on control of available P that leads to excessive fertilization and impaired water quality.

Another key issue that should be evaluated in developing nutrient criteria is the impact of the phosphorus loads on phytoplankton biomass in the Delta. Reducing the phosphors loads to the Delta will reduce phytoplankton biomass but will also, in turn, reduce fish production. These issues were discussed by E. Van Nieuwenhuyse in his papers and presentation at the Delta nutrient workshop.

The authors reviewed the Delta Stewardship Council staff drafts of Delta water quality issues that need to be addressed in developing a Delta Plan to manage water quality and export water for to the Central Valley and Southern California and the San Francisco Bay areas.

Lee, G. F., and Jones-Lee, A., "Comments on the Delta Stewardship Council's Third Staff Draft Delta Plan – Chapter 6 Improve Water Quality to Protect Human Health and the Environment – Released April 22, 2011," Submitted to Delta Stewardship Council, Sacramento, CA, Report of G. Fred Lee & Associates, El Macero, CA, Updated May 1 (2011). http://www.gfredlee.com/SJR-Delta/DSCThrdStaffDraft-Com.pdf

Lee, G. F., and Jones-Lee, A., "Comments on the DSC Staff Fifth Draft of Chapter 6 Devoted to Delta Water Quality Issues in the Delta Plan," Comments Submitted to Delta Stewardship Council, Sacramento, CA, by G. Fred Lee & Associates, El Macero, CA, August 21 (2011). http://www.gfredlee.com/SJR-Delta/DeltaPlan5DraftCh6Comm.pdf

Lee, G. F., and Jones-Lee, A., "Comments on Revised Delta Plan Staff Draft Chapter 6 'Improve Water Quality to Protect Human Health and the Environment' as Presented in the Fourth Staff Draft of the Delta Plan," Comments Submitted to Delta Stewardship Council, Sacramento, CA, by G. Fred Lee & Associates, El Macero, CA, June 14 (2011). http://www.gfredlee.com/SJR-Delta/DeltaPlan4DraftCh6Comm.pdf

One of the issues discussed in our comments is the management of nutrient related water quality problems. E. Van Nieuwenhuyse *"The California Water Environmental Modeling Forum (CWEMF) develops peer reviews of modeling approaches and develops workshops on water modeling issues; Dr. Lee was asked to serve as a member of the CWEMF steering committee. With Dr. Jones-Lee he developed for the CWEMF a workshop entitled, "Overview of Delta Nutrient Water Quality Problems: Nutrient Load - Water Quality Impact Modeling," which was presented to an audience of about 100 in March 2008. Information on that workshop is available on the CWEMF website [http://www.cwemf.org] at: http://www.cwemf.org/workshops/NutrientLoadWrkshp.pdf. Additional information on the workshop is available at:*

> *Lee, G. F., and Jones-Lee, A., "Delta Nutrient-Related Water Quality Problems," PowerPoint Slides Presented at CALFED Science Conference, Sacramento, CA, October 24 (2008). http://www.gfredlee.com/SJR-Delta/CALFED_SciConf10-08.pdf*
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> *Lee, G. F., and Jones-Lee, A., "Synopsis of CWEMF Delta Nutrient Water Quality Modeling Workshop – March 25, 2008, Sacramento, CA," Report of G. Fred Lee & Associates, El Macero, CA, May 15 (2008). http://www.gfredlee.com/SJRDelta/ CWEMF_WS_synopsis.pdf*
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> *"Overview of Delta Nutrient Water Quality Problems: Nutrient Load – Water Quality Impact Modeling," Agenda for Technical Workshop sponsored by California Water and Environmental Modeling Forum (CWEMF), Scheduled for March 25, 2008 in Sacramento, CA (2008). http://www.gfredlee.com/SJR-Delta/CWEMF_Workshop_Agenda.pdf*
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> *Lee, G. F., and Jones-Lee, A., "Delta Nutrient-Related Water Quality Problems," PowerPoint Slides Presented at CALFED Science Conference, Sacramento, CA, October*

As noted in the authors' review of DSC third draft Chapter 6 the work of Dr. Van Nieuwenhuyse should be mentioned at this location in Chapter 6. We stated in our comments on the third staff draft of Chapter 6:

"*In his CWEMF nutrient workshop presentation entitled, "Impact of Sacramento River Input of Phosphorus to the Delta on Algal Growth in the Delta," Dr. Erwin Van Nieuwenhuyse summarized his recent paper describing the response of average summer chlorophyll concentration in the Delta to an abrupt and sustained reduction in phosphorus discharge from the Sacramento County Regional Sanitation District wastewater treatment facility. His presentation provides important information on the impact of Sac Regional phosphorus discharge on Delta planktonic algae in the Delta, and is available at, http://www.cwemf.org/workshops/DeltaNutrientsWrkshp/VanNieuwenhuyse.pdf.*

"As discussed in the van Nieuwenhuyse workshop presentation and published paper, vanNieuwenhuyse, E., "Response of Summer Chlorophyll Concentration to Reduced Total Phosphorus Concentration in the Rhine River (Netherlands) and the Sacramento–San Joaquin Delta (California, USA)," Can. J. Fish. Aquatic, Sci. 64(11):1529-1542 (2007).

[http://www.ingentaconnect.com/content/nrc/cjfas/2007/00000064/00000011/art00006]

and the Lee and Jones-Lee workshop presentation, backup information, and papers referenced in their presentations, it is well-established that reducing the phosphorus loads and in-waterbody concentrations effects reductions in the phytoplankton biomass in Delta waters. This occur even in situations in which the available phosphorus concentrations in the waterbody remain surplus compared to growth-rate-limiting concentrations. The decrease in planktonic algae in the Delta associated with decreased phosphorus loads to the Delta is important information that must be discussed in a creditable discussion of the impact of nutrients on Delta water quality.

The changes in the Delta ecosystem that occurred associated with Sac Regional decreased phosphorus discharges rather than the change in N/P ratios as discussed in the DSC staff third draft are a more likely cause of changes in the fish production than the change in the N/P ratios discussed by the staff in the third draft."

Overall the scope of the SWRCB should specifically include a discussion of the issues raised in these comments.

Drs. Lee and Jones-Lee Experience in Establishing
Nutrient Water Quality Criteria/Standards

We have investigated the impacts of nutrient loads on eutrophication-related water quality of many waterbodies. Our single most comprehensive effort was a US EPA-sponsored review and synthesis of nutrient load and response data collected on US waterbodies as part of the Organization for Economic and Development (OCED) international eutrophication study. The OECD eutrophication study was a 5-year, $50-million investigation of about 200 waterbodies in North America, Western Europe, Japan, Australia, to evaluate the impacts of nutrient loads on the algae-related water quality of lakes and reservoirs. Using Vollenweider's normalized load–response model developed through his OECD eutrophication study work, Lee and his colleagues described empirical relationships between normalized P load and eutrophication-related water quality characteristics for a diverse group of lakes and reservoirs across the US, relationships that were in keeping with those subsequently developed upon the entire OECD study database. They also expanded the original Vollenweider–OECD eutrophication study model concepts to include several additional fertilization impacts including water clarity, hypolimnetic oxygen depletion rates. The synthesis report for US waterbodies was published by the US EPA as,

> Rast, W. and Lee, G. F., "Summary Analysis of the North American (US Portion) OECD Eutrophication Project: Nutrient Loading-Lake Response Relationships and Trophic State Indices," EPA 600/3-78-008, US EPA-Corvallis (1978).

A summary paper covering that report was published as a featured article:

> Lee, G. F.; Rast, W. and Jones, R. A., "Eutrophication of Water Bodies: Insights for an Age-Old Problem," Environ. Sci. & Technol. 12:900-908 (1978).
> http://www.gfredlee.com/Nutrients/Eutrophication-EST.pdf

The final overall OECD report was published as:

> OECD, "Eutrophication of Waters, Monitoring, Assessment, and Control," Organization for Economic Cooperation and Development, Paris (1982).

Following the completion of their work on the US OECD database, Dr. Lee and colleagues continued the OECD-type eutrophication studies of waterbodies and expanded the total database foundation of the model beyond the OECD database, to more than 700 waterbodies of varied character located in areas covering most of the world. Several of his papers that describe that work include:

> Jones, R. A., and Lee, G. F., "Recent Advances in Assessing the Impact of Phosphorus Loads on Eutrophication-Related Water Quality," Journ. Water Research 16:503-515 (1982). http://www.gfredlee.com/Nutrients/RecentAdvWaterRes.pdf

> Jones, R. A. and Lee, G. F., "Eutrophication Modeling for Water Quality Management: An Update of the Vollenweider-OECD Model," World Health Organization's Water Quality Bulletin 11:67-174, 118 (1986).
> http://www.gfredlee.com/Nutrients/voll_oecd.html

More recently a summary of our work on excessive fertilization of waterbodies was published in:

Jones-Lee, A., and Lee, G. F., "Eutrophication (Excessive Fertilization)," Water Encyclopedia: Surface and Agricultural Water, Wiley, Hoboken, NJ pp 107-114 (2005). http://www.gfredlee.com/Nutrients/WileyEutrophication.pdf

Lee and Jones-Lee have further expanded the Vollenweider–OECD normalized load–response relationships to define such a relationship between phosphorus loads and the fish production in waterbodies:

Lee, G. F. and Jones, R. A., "Effects of Eutrophication on Fisheries," Reviews in Aquatic Sciences, 5:287-305, CRC Press, Boca Raton, FL (1991). http://www.gfredlee.com/Nutrients/fisheu.html

That paper demonstrated that, as expected, altering the phosphorus loads to waterbodies impacts the fish production in a waterbody. We discussed the importance of considering impacts on fish production when reducing nutrient loads or establishing nutrient criteria for a waterbody.

They also demonstrated the utility of the modeling approach in assessing ecosystem functioning:

Jones, R. A. and Lee, G. F., "Use of Vollenweider-OECD Modeling to Evaluate Aquatic Ecosystem Functioning," Functional Testing of Aquatic Biota for Estimating Hazards of Chemicals, ASTM STP 988, Amer. Soc. Test. & Mat., Philadelphia, pp. 17-27 (1988). http://www.gfredlee.com/Nutrients/EcosystemFunctionOECD.pdf

Lee and his colleagues investigated and documented the predictive capability of the Vollenweider–OECD eutrophication modeling approach, and applied and described the use of the model for water quality evaluation and management.

Rast, W., Jones, A., and Lee, G. F., "Predictive Capability of US OECD Phosphorus Loading-Eutrophication Response Models," Journ. Water Pollut. Control Fed. 55(7):990-1003 (1983). http://www.gfredlee.com/Nutrients/PredictiveCapabilityOECD.pdf

Lee and his graduate students applied the Vollenweider–OECD modeling approach to managing excessive fertilization of water supply reservoirs in, for example:

Archibald, E. M. and Lee, G. F., "Application of the OECD Eutrophication Modeling Approach to Lake Ray Hubbard, Texas," Journ. AWWA 73:590-599 (1981). http://www.gfredlee.com/Nutrients/OECDLakeRayHub.pdf

Throughout his work it has been clear that a key factor that must be considered in assessing the impacts of phosphorus on waterbodies is the role of total phosphorus versus algal-available phosphorus in impacting the fertilization of waterbodies. This issue was understood and discussed in the technical literature 30 years ago:

Lee, G. F., Jones, R. A., and Rast, W., "Availability of Phosphorus to Phytoplankton and its Implications for Phosphorus Management Strategies," IN: Phosphorus Management Strategies for Lakes, Ann Arbor Science Publishers, Inc., Ann Arbor, MI (1980). http://www.gfredlee.com/Nutrients/Avail-P.pdf

A number of our more recent papers/reports discuss technical deficiencies in the US EPA's position that all forms of particulate phosphorus are available, or become available, to support algal growth. We have become involved in the issues of the development of appropriate approaches for controlling phosphorus from agricultural land runoff to improve those conditions, focusing in part on the comparative effects of controlling total phosphorus versus algal-available P in runoff waters. These issues have been discussed in:

Lee, G. F., "Assessing Algal Available Phosphorus," Submitted for Inclusion in the Proceedings of US EPA Science Symposium: "Sources, Transport, and Fate of Nutrients in the Mississippi River and Atchafalaya River Basins," Minneapolis, MN, November 7-9 (2006). http://www.gfredlee.com/Nutrients/AvailPEPASymp06.pdf

Lee, G. F., "A Proposal for Assessing Algal-Available Phosphorus Loads in Runoff from Irrigated Agriculture in the Central Valley of California," Report of G. Fred Lee & Associates, El Macero, CA, November (2006).
http://www.gfredlee.com/Nutrients/AlgalAssayAvailP.pdf

Lee, G. F., "Assessing Algal Available Phosphorus," Proceedings of US EPA Science Symposium: Sources, Transport, and Fate of Nutrients in the Mississippi River and Atchafalaya River Basins, Minneapolis, MN, November 7-9 (2006).
http://www.gfredlee.com/Nutrients/AvailPEPASymp06.pdf

Cowen, W. F., and Lee, G. F., "Phosphorus Availability in Particulate Materials Transported by Urban Runoff," Journ. Water Pollut. Control Fed. 48(3):580-591 (1976).
http://www.gfredlee.com/Nutrients/AvailPParticulatesCowen.pdf

They have also been discussed in our Stormwater Runoff Water Quality Newsletters NL- 1-2, 1-5, 4-3/4, 5-1, 6-1, 6-2, 7-6/7, 9-1/2, 9-7, 9-8, 9-10, 10-1, 10-2, 10-4, 10-5, 10-6, 10-13, 11-2, 11-5, 11-7/8, 11-9,11-10. 12-3, 12-5, 12-6, 12-7/8 available at
http://www.gfredlee.com/newsindex.htm. As discussed in those sources, and elsewhere, the literature shows that the US EPA position of requiring phosphorus regulation based on total phosphorus, rather than algal-available phosphorus, is not technically valid and can cause agricultural and urban interests to spend large amounts of money for phosphorus control beyond that needed to control excessive fertilization of waterbodies.

In 2002 Lee and Jones-Lee published a paper discussing the development of technically valid nutrient criteria/standards:

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

That paper discussed why the US EPA statistical approach for developing nutrient criteria as set forth in,

"U.S. EPA. 2000a. Nutrient Criteria Technical Guidance Manual: Lakes and Reservoirs. Office of Water, Washington, DC. EPA-822-B-00-001.

U.S. EPA. 2000b. Nutrient Criteria Technical Guidance Manual: Rivers and Streams. Office of Water, Washington, DC. EPA-822-B-00-002.

U.S. EPA. 2001. Nutrient Criteria Technical Manual: Estuarine and Coastal Marine Waters. Office of Water, Washington, DC. EPA-822-B-01-003), and wetlands (U.S. EPA, 2007)

and in our comments on the US EPA RTAG efforts available on our website discussed why a site-specific approach that considers the waterbody characteristics and water quality management objectives should be used, and how such an approach could be developed and implemented. That approach has been adopted by the California State Water Resources Control Board as discussed in:

SWRCB, "Estuarine Nutrient Numeric Endpoint Coastal Stakeholder Advisory Group (Coastal SAG) Meeting May 1, 2009," PowerPoint Slides, SWRCB, Sacramento, CA, May (2009). http://www.gfredlee.com/Nutrients/CoastalSAGMeeting5-1-2009.pdf

SWRCB, "Estuarine NNE Project - NNE STRTAG Meeting Conference Call August 17, 2009," California State Water Resources Control Board (SWRCB) Coastal Nutrient Development Program Sacramento, CA, August 17 (2009). http://www.gfredlee.com/Nutrients/STRTAG8-17-09Mtg.pdf

The State of California has Water Resources Control Board rejected the US EPA RTAG statistics-based approach in favor of a site-specific approach for coastal waterbodies. This issues have been discussed in our Stormwater Runoff Water Quality Newsletters, NL-1-3, 5-1, 9-1/2, 9-8, 10-4, 10-5, 10-6, 10-7, 10-13, 11-2, 11-5, 11-9, 12-3, 12-5, 12-6, and 12-7/8.

An ancillary finding that evolved from Vollenweider's work in the OECD eutrophication studies was the relationship between the phosphorus load to a lake or reservoir and the phosphorus concentration in the waterbody. Vollenweider found that in theory and in the OECD data, the phosphorus load to a waterbody, properly normalized by the waterbody's area, mean depth, and hydraulic residence time (filling time), is approximately equal to the average phosphorus concentration in the waterbody. Chapra (1997), in his book, "Surface Water Quality Modeling," confirmed that relationship. However, as we have discussed elsewhere, P concentration in a waterbody, especially instantaneous concentration, is not a reliable eutrophication-related water quality indicator. A key issue that needs to be addressed in considering nutrient criteria is how to relate phosphorus and nitrogen in-waterbody concentrations to a waterbody to their impact on the waterbodies beneficial uses. Phosphorus, in itself, is not a water quality concern; it is only of concern to the extent that it is used by algae and aquatic plants in the production of nuisance or other adverse impacts of excessive amounts of biomass.

Vollenweider's work in the OECD eutrophication studies revealed that the relating factors between P load and eutrophication-related water quality response were the site-specific morphologic and hydrologic characteristics of the waterbody in question, namely the waterbody's area, mean depth, and hydraulic residence time; that finding has been corroborated in substantial amounts of follow-on work. Thus in order to implement the proposed criteria into source discharge limitations for various dischargers, it is necessary to consider the target waterbody's area, mean depth, and hydraulic residence time to relate the phosphorus load to the waterbody to its eutrophication-related water quality characteristics. As noted above, that normalized P loading is also related to in-lake phosphorus concentrations through

Vollenweider's empirical relationships, although that is not a reliable eutrophication-related water quality response parameter. Additional papers and reports that address these issues are available at www.gfredlee.com in the Excessive Fertilization/Eutrophication section [http://www.gfredlee.com/pexfert2.htm].

It is somewhat surprising that the vast literature and the results of the international OECD eutrophication study were not even mentioned in the proposed Florida nutrient criteria rule. That body of work, briefly described above, represents the most expansive and comprehensive study and verification ever undertaken of the quantitative relationships between phosphorus loads and eutrophication-related water quality characteristics, especially planktonic algal chlorophyll, and in-lake P concentrations. That body of work, as well as other studies, clearly shows that nitrogen loads and in-lake nutrient concentrations are poor predictors of planktonic algal chlorophyll that develops in lakes and reservoirs. Rast and Lee, referenced above, for example, specifically examined the predictive ability of nitrogen loads and in-lake nitrogen concentrations and planktonic algal chlorophyll that develops in waterbodies and found that there was no common relationship.

While it is of interest to examine the relationships between nutrient loads/concentrations to/within a waterbody and nutrient-related water quality characteristics of the waterbody, great caution must be exercised in using statistical relationships developed from such exercises to establish regulatory requirements enacted for the purpose of achieving desired nutrient-related water quality characteristics. Employment of technically inappropriate statistical relationships can readily lead to arbitrary nutrient discharge restrictions that can trigger large expenditures for "nutrient control" from domestic wastewaters, urban and agricultural runoff/discharges, and others without the expectation or achievement of the desired water quality.

Over the past five decades that Dr. G. Fred Lee has been active in examining nutrient load – response relationships, he has repeated observed the unreliability of statistical correlations developed between nutrient concentrations and assumed responses. It has been his experience that the current "Empirical Approach" being used by the US EPA can readily lead to unreliable approaches for developing nutrient criteria for the management of excessive fertilization of waterbodies. It is not a matter of the approaches' yielding overly protective, or under-protective regulation and management. The problem is that they are not technically sound; a technically unsound approach cannot be expected to render reliable criteria/standards, or conclusions regarding the necessity for or water quality impacts of nutrient loads or management steps that could be required to achieve arbitrary criteria/standards.

There are many other "statistical approach" relationships reported in the literature that are not valid for relating nutrient loads/concentrations to fertilization response. Statistical "relationships" can be developed that have little or no capability to reliably predict changes in nutrient-related water quality characteristics that would result from changes in nutrient loads. Such a demonstration is of paramount importance for the development of nutrient criteria developed for the purpose of controlling nutrient-related water quality. Any statistical relationship between nutrient load and waterbody response must be solidly grounded in fundamental mechanisms (cause-effect) that influence how a nutrient could impact a fertilization response. Without such a foundation, the statistical relationship is simply game playing.

The statistical manipulations at the foundation of the various iterations of the US EPA's approach for nutrient criteria have typically disregarded the need for a foundation in cause-and-effect relationships. An example is the US EPA's recent attempt to develop nutrient criteria for streams based on spurious correlations. We commented on the fundamental technical flaws of mechanically using statistics to provide the illusion of a meaningful "relationship" between total phosphorus and nitrogen concentrations and the impact of those chemicals on a stream's ecosystem. The NAS NRC review of that approach also concluded it is not valid for developing nutrient criteria. Our comments on these issues are provided in:

> 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
>
> Hall, J., "Request for Peer Review of New EPA Region III Approach to Developing Instream Standards for Nutrients," Letter with attachments to Stephen Johnson, Administrator, US EPA, Washington, DC, Submitted by Hall & Associates, Washington, DC, August 21 (2008).
> http://www.gfredlee.com/Nutrients/Hall_Cond_Prob_Eval.pdf
>
> Lee, G. F., and Jones-Lee, A., "Comments on US EPA's Conditional Probability Approach for Developing Phosphorus Nutrient Criteria," Report of G. Fred Lee & Associates, El Macero, CA, September 26 (2008).
> http://www.gfredlee.com/Nutrients/PCriterionCondProb.pdf

Overall, the US EPA should abandon it present efforts to develop nutrient criteria based on "statistical approaches" and focus on supporting research to reliably define the adverse and beneficial impacts caused by addition of nutrients to waterbodies.

A substantial portion of Drs. Lee and Jones-Lee's professional work has been, and continues to be, in the area of evaluation and management of the impacts of aquatic plant nutrients (nitrogen and phosphorus) on water quality/beneficial uses of waterbodies, including lakes, reservoirs, coastal marine waters, as well as riverine systems. Excessive fertilization (eutrophication) causes adverse impacts on recreational uses and aesthetics, raw water supply water quality (tastes & odors and THM formation), and fisheries resources through, among other things, food supply and oxygen depletion associated with algal decomposition. As discussed below, their work focuses on the causes, manifestation, and control of the wide range of excessive fertilization problems.

Dr. Lee's work in eutrophication evaluation and management began in the 1960s when he established, developed, and directed the Water Chemistry Program in the Department of Civil and Environmental Engineering at the University of Wisconsin, Madison. During the 13 years under his direction, that program was highly involved in lake and reservoir water quality investigation and management; approximately 100 of his graduate students did their Masters theses or Ph.D. dissertations on various aspects of lake and reservoir water quality. One of the principal focal points of that work was excessive fertilization issues. Dr. Lee pioneered in the development of approaches for evaluating the impact of a various sources of nutrients, including activities and conditions in a waterbody's watershed, on waterbodies' water quality.

In 1960, Dr. Lee was appointed vice-chair of the Lake Mendota Water Quality Management Committee. Lake Mendota is one of the most intensively studied waterbodies in the world due to the long history of limnological research conducted by the University of Wisconsin, Madison, faculty and students. From 1960 through the early 1970s many of the water chemistry studies conducted on Lake Mendota were under the direction of Dr. Lee. During that time Dr. Lee was also involved in Great Lakes water quality issues, and served as an advisor to the International Joint Commission for the Great Lakes and the US EPA on excessive fertilization issues. Over the years he has been an investigator or advisor on eutrophication-related water quality issues in many areas of the US as well as in the Netherlands, Norway, Italy, Spain, Israel, Jordan, Japan, the USSR, Dominican Republic, South Africa, Argentina, and Antarctica.

On behalf of the Water Resources Center at the University of Wisconsin, Madison, Dr. Lee developed the first comprehensive overview of the causes, processes, implications, and management of the eutrophication of waterbodies in the paper:

> Lee, G.F., "Eutrophication," University of Wisconsin Eutrophication Information Program Occasional Paper no. 2, 32 pp (1970) [also published in Transactions of the Northeast Fish and Wildlife conference, pp 39-60 (1973), and available upon request from gfredlee@aol.com as EF014]

More recently, he and Dr. Jones-Lee were asked to contribute the following review of eutrophication:

> Jones-Lee, A. and Lee, G. F., "Eutrophication (Excessive Fertilization)," In: Water Encyclopedia: Surface and Agricultural Water, Wiley, Hoboken, NJ, pp 107-214 (2005). [available at: http://www.gfredlee.com/Nutrients/WileyEutrophication.pdf]

Those reviews discuss the roles of nitrogen, phosphorus, and other constituents and factors in causing excessive fertilization-related water quality problems, as well as, and most importantly, approaches that can be used to manage excessive fertilization and evaluate the effectiveness of management strategies. Those two writings remain the most comprehensive reviews of eutrophication and its management.

Dr. Lee was also involved in the lake and reservoir management studies conducted by the state of Wisconsin in the late 1960s to early 1970s. As part of that program, whole-lake experimental approaches were used to assess the efficacy of a variety of strategies for evaluating and managing water quality in excessively fertile lakes; strategies evaluated included adding alum to lakes to remove phosphorus, aeration of lakes to mix the hypolimnion and epilimnion, hypolimnetic aeration, aquatic plant harvesting, among others. Dr. Lee was involved in a number of additional projects in the state of Wisconsin in which alum was used to treat whole lakes for phosphorus removal; he supervised the masters thesis work of one of his students on this topic. Dr. Lee has developed specific guidance for discerning situations in which alum treatment for phosphorus removal can be effective, and where it should not be used. Critical to this assessment is the relative role of phosphorus in controlling excessive fertilization in the waterbody.

For a number of years beginning in the 1970s, Dr. Lee was a member of the American Water Works Association's national ‘Quality Control in Reservoirs’ Committee. During that time, the committee specifically addressed the value of mixing of lakes, either by aeration or pumping, for the purpose of managing eutrophication-related water quality problems. It was the committee's conclusion, supported by the fundamental chemistry of nutrients, that aeration of a whole waterbody could be significantly adverse to improving eutrophication-related water quality characteristics. Oxygenation of the hypolimnion, however, could be effective in maintaining cold-water fisheries and improving water supply water quality by reducing nutrient transport from the hypolimnion to the epilimnion. In 1965 Dr. Lee published a paper,

> Lee, G.F. and Harlin, C.C., "Effect of Intake Location on Water Quality," Industrial Water Engineering 2:36-40 (1965). [available upon request to gfredlee@aol.com as publication DW003].

which specifically addressed the importance of evaluating domestic water supply water quality as a function of depth, and how, through selective withdrawal, water utilities can optimize their water quality in a thermally stratified waterbody.