

G. Fred Lee's Expertise and Experience in
Investigating & Managing Excessive Fertilization in Waterbodies
and Developing Nutrient Criteria

June 22, 2014

TO: Brock Berstein, Steve Camacho – State Water Resources Control Board

Following up on the organization of the SWRCB nutrient objectives SAG, I wish to mention that I have been active in the investigation and management of excessive fertilization of waterbodies since the early 1960s. A major focus of my work over the past 50 years has been the development and evaluation of nutrient criteria/standards and numeric objectives for nutrient control programs. Attached is a brief summary of my expertise and experience in this work. Additional information as well as the writings mentioned are available on Dr. Anne Jones-Lee's and my website, www.gfredlee.com in the Nutrient and Eutrophication section at <http://www.gfredlee.com/pexfert2.html>.

As noted in the attached summary, we have frequently served as advisors on nutrient impact/management issues across the US and in many other countries. These activities have included conducting research on nutrient sources, availability, and removal from domestic wastewaters, agricultural and urban stormwater runoff, and serving as a member of a national and international committee devoted to developing nutrient criteria/standards and nutrient aquatic chemistry and availability to planktonic algae. I/we have developed more than 80 papers and reports on nutrient-related water quality issues. Over the past 25 years we have been particularly active on excessive fertilization issues of the San Joaquin River and the Delta; we have developed more than 135 papers/reports on our Delta work.

If you feel that my experience may be of interest to members of the Nutrient Objectives SAG, please provide this summary to them and indicate that if they have questions on any of these activities and/or a particular excessive fertilization situation, they may contact me.

G. Fred Lee and Anne Jones-Lee

copy to M. Sutula

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Dr. G. Fred Lee has been involved in pioneering research, graduate university teaching, consulting for governmental agencies and industry, and professional service in issues of excessive fertilization and aquatic plant nutrients (nitrogen and phosphorus compounds) for more than five decades. His experience and expertise include

- assessment of the availability of nutrients in environmental media to stimulate growth of aquatic plants (algae and rooted aquatic plants), and real-world evaluation of the reliability of various approaches for availability assessment;
- quantification and availability assessment of nutrient inputs from urban and agricultural lands, the atmosphere, sediments, groundwater, domestic and industrial wastewaters;
- modeling the input, behavior, and impacts of aquatic plant nutrients in receiving waters with both empirical and stochastic approaches;
- developing workable approaches for managing nutrient inputs to effect improvements in beneficial uses of receiving water including drinking water supply, fisheries, and recreation;
- the quantitative determination of the improvement in beneficial uses of receiving waters that have resulted from given changes in nutrient loading and waterbody management;
- evaluation of these issues for lakes, reservoirs, rivers, estuaries, and nearshore marine environments in the US and worldwide;
- development, and evaluation of the reliability of various approaches for, nutrient criteria and standards; and
- publication of more than 150 professional papers and reports on these issues, many of which are available on his website, www.gfredlee.com in the Nutrients/Excessive Fertilization section [<http://www.gfredlee.com/pexfert2.html>].

After earning his PhD degree from Harvard University in 1960, Dr. Lee was appointed Professor of Water Chemistry at the University of Wisconsin, Madison. During the following 13 years he developed and directed the UWM Water Chemistry program; information on that program and Dr. Lee's involvement in it is available at:

Lee, G. F., and Jones-Lee, A., "Development of the Water Chemistry Program at the University of Wisconsin Madison & Follow-on Activities of Dr. Lee in Developing the Water Chemistry Field," Report of G. Fred Lee & Associates, El Macero, CA, January 1 (2012). <http://www.gfredlee.com/Education/WaterChemProgramDevel.pdf>

Lake Mendota in Madison, WI is one of the most studied lakes in the world; innumerable graduate students and professors in science and engineering disciplines have studied its limnology, chemistry, bacteriology, botany, zoology, geology, meteorology, and hydrology since the 1920s. Thirty of Dr. Lee's graduate students at UCM conducted their MS or PhD studies on Lake Mendota water quality, most of which were devoted to some aspect of the lake's eutrophication. Dr. Lee also served for many years as vice-chair of the Lake Mendota Problems Committee instituted by the city of Madison devoted to identifying aspects of existing and emerging water quality issues, largely eutrophication-related, that were important for university

faculty to investigate for the purpose of developing water quality improvement strategies.

For 20 years following his work at UWM, Dr. Lee held graduate professorial positions at several other universities where his investigation of eutrophication and nutrient-related water quality issues continued. In all about half of his 90 graduate students conducted their MS or PhD research on issues of excessive fertilization. Many of those studies resulted in peer-reviewed papers that are available on his website www.gfredlee.com in the Nutrients Excessive Fertilization section at <http://www.gfredlee.com/pexfert2.html>.

Lee has worked with Dr. Anne Jones-Lee on much of his eutrophication work since the mid-1970s. Their activity in this area continued after they retired from university positions to expand their private consulting, which continues at this time.

Following is a summary of some of the studies in which Dr. Lee has, over his five-decades-long professional career, played a principal role as a primary researcher, advisor, and/or consultant to governmental agencies, commercial, industrial, or agricultural clients on managing excessive fertilization of waterbodies:

Lake Mendota Problems Committee

- Research on the aquatic chemistry of nutrients (N and P and organics) focusing on defining sources and availability of nutrients to support algal growth
- Definition of nutrient sources for Lake Mendota
- Identification of impacts of excessive algal growth on the lake's water quality/beneficial uses
- Definition and qualification of the rate of eutrophication of the lake

State of Wisconsin Department of Natural Resources

- Research on the fate & impacts of herbicides/algaecides on water quality and aquatic life, including arsenic used to control aquatic weeds, copper used to control algae, and organic herbicides/endothall
- Research on hypolimnetic aeration of a lake for the improvement of fish habitat
- Evaluation of the role of septic tank wastewater disposal systems in lake fertilization

US EPA

- Evaluation of the relative significance of carbon dioxide and phosphorus as in causing excessive algal growth in Lake Erie
- Research, as part of the IFYGL, on the role of phosphorus in stimulating excessive growth of Cladophora in the nearshore waters of Lake Ontario
- Assess role of thermal discharges from power plants using once-thru cooling on the excessive fertilization of Lake Michigan
- Development of synthesis report on the US part of the OECD international Eutrophication Studies quantifying the relationships between phosphorus and nitrogen loads to lakes and reservoirs and planktonic algal growth
- US/US EPA member of the International OECD Eutrophication Studies steering committee for the \$50-million, five-year study conducted by 22 countries in western Europe, North America, Japan and Australia to evaluate the relationship between N and P

loads and planktonic algal growth in lakes and reservoirs

- Advised on evaluation of the efficacy of various approaches for lake restoration

SJR Delta, California

- Principal Investigator for CALFED-supported, \$2-million, two-year study of the low DO problem in the San Joaquin River Ship Channel
- Organized two-day “Delta Nutrient Water Quality Modeling Workshop on behalf of California Water Quality Modeling Forum

New Jersey Sea Grant

- Conducted research on excessive fertilization of NY/NJ Harbors
- Investigated roles of phosphorus and nitrogen in excessive fertilization
- Assessed impacts of marsh draining on downstream water quality

Reserve Mining Co.

- Evaluate impacts of taconite tailing discharges on algal growth in Lake Superior

Work in Other Countries:

- Israel: Advised on managing excessive fertilization of Lake Kinneret (Sea of Galilee)
- Jordan: Advised on managing excessive fertilization King Talal Reservoir
- South Africa: Advised on managing excessive fertilization of South African reservoirs, and application of OECD eutrophication study results to South African impoundments; presented one-week short course on managing excessive fertilization in reservoirs
- Argentina: Advised on managing excessive fertilization of reservoirs, present a one week short course on managing excessive fertilization of lakes and reservoirs
- Dominican Republic: Advised on managing a new water supply reservoir water quality
- USSR Academy of Sciences: Presented one-week short course at the Institute of Ecology for the Volga River on managing excessive fertilization of Volga River impoundments
- Norway: Advised on managing eutrophication in deep lakes
- The Netherlands Government Rijkswaterstaat: Advise on development of environmental quality management programs for the Delta Works dams on the Rhine River Estuary
- Argentina: Pan American Health Organization - World Health, advise government of Argentina on water quality management in impoundments
- France, Foundation de L'Eau: Advised on impacts of detergent phosphate bans on water quality

US–Canada International Joint Commission for the Great Lakes

- Advised on eutrophication-related water quality research for the Great Lakes

President’s Council on Environmental Quality

- Advised on the role of phosphate in the eutrophication of natural waters

City of Dallas, TX

- Conducted a several-year research project devoted evaluation nutrient sources and

impacts on water quality Lake Ray Hubbard, a city water supply reservoir

State of New Mexico

- Advise on approach for assessing nutrient loads and their effects on water quality in New Mexico impoundments

State of Florida

- Advise on control of nutrients from drained wetlands

Northwest Colorado Council of Governments

- Advise on development of eutrophication study program for Dillon Reservoir

City of Olathe, Kansas

- Development of water quality management program for Lake Olathe

Procter & Gamble Company

- Evaluated the role of detergent phosphate as a significant source of phosphorus promoting excessive algal growth in lakes; made presentations of findings in the USA, Netherlands, Italy, Japan including the Seto Inland Sea and Lake Biwa
- Evaluated the potential impact of NTA as a substitute for detergent phosphate

Agricultural Issues

- Commented on the reliability of US EPA-proposed nutrient criteria for the state of Florida

American Chemical Society (ACS) Invited Lecture Tour Speaker

- Served for more than 20 years as an invited tour speaker for the American Chemical Society lecturing at 24 ACS local sections on excessive fertilization of waterbodies

Topics of Key Papers, Reports, Presentations (available at www.gfredlee.com)

Agricultural Sources of Nutrients

- “Assessing Algal Available Phosphorus,” Published in the Proceedings of US EPA Science Symposium: Sources, Transport, and Fate of Nutrients in the Mississippi River and Atchafalaya River Basins
- “Assessing the Water Quality Significance of N & P Compound Concentrations in Agricultural Runoff,” Invited Paper Presented at Agrochemical Division, American Chemical Society National Meeting, San Francisco,
- “Nutrient TMDLs and BMPs,” Presentation to the UC Agricultural Extension farm advisors and researchers, Woodland, CA
- “Interpretation of Nutrient Water Quality Data Associated with Irrigated Agricultural Ag Waiver Monitoring,” Submitted to Central Valley Regional Water Quality Control Board
- “Assessing the Water Quality Impacts of Phosphorus in Runoff from Agricultural Lands,” Published in: Environmental Impact of Fertilizer on Soil and Water, American Chemical Society Symposium Series
- “Assessing the Water Quality Impacts of Phosphorus in Runoff from Agricultural Lands: Expanded Discussion,” Presented in part at American Chemical Society Agro Division Symposium, “Environmental Impact of Fertilizer Products in Soil, Air and Water,”

Chicago, IL

- “Assessment and Analysis of Eutrophication of Tennessee River System Impoundments,” Proc. ISCHIA Symposium on Surface Water Impoundments

Sediments as Nutrient Sources

- “The Significance of Dredging and Dredged Material Disposal as a Source of Nitrogen and Phosphorus for Estuarine Waters,” Published in: *Estuaries and Nutrients*
- “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

Eutrophication Reviews

- “Eutrophication,” Transactions of the Northeast Fish and Wildlife Conference (1973)
- “Eutrophication,” University of Wisconsin Eutrophication Information Program Occasional Paper No. 2
- “Eutrophication (Excessive Fertilization),” Encyclopedia of Water, John Wiley & Sons, New York, NY

Nutrient Criteria and Nutrient TMDLs

- “Developing Nutrient Criteria/TMDLs to Manage Excessive Fertilization of Waterbodies,” Proceedings Water Environment Federation, TMDL 2002
- “Evaluating Nitrogen and Phosphorus Control in Nutrient TMDLs,” Journal Stormwater
- “Evaluation of Inorganic and Organic Nutrient Source Impacts in Nutrient TMDLs,” Proceedings of the AWWA/WEF/CWEA Joint Residuals and Biosolids Management Conference
- “Comment of the Technical Reliability of the US EPA Approach for Developing Nutrient Criteria for the New EPA Region III Approach to Developing Instream Standards for Nutrients”
- “Comments on US EPA’s Conditional Probability Approach for Developing Phosphorus Nutrient Criteria”
- “Evaluation and Management of Non-Point Source Pollutants in the Lake Tahoe Watershed,” Proc. 1994 National Conference on Environmental Engineering, “Critical Issues in Water and Wastewater Treatment,” American Society of Civil Engineers, New York, NY
- “Role of Vehicular Exhaust NO_x and Lawn-Shrubbery Fertilizers as a Cause of Water Quality Deterioration in Lake Tahoe”
- “The Relationship between Phosphorus Load and Eutrophication Response in Lake Vanda,” *Phys. Biogeochem. Processes in Antarctic Lakes*, Antarctic Research Series
- “Impact of a Phosphate Detergent Ban on Concentrations of Phosphorus in the James River, Virginia”
- “Development of Lake Water Quality Management Programs,” Report & Presentation prepared for NJ Coalition of Lake Associations
- “Relationship between Summer Mean and Maximum Chlorophyll a Concentrations in Lakes,” *Environ. Sci. & Technol.*

Domestic Water Supply Water Quality

- "Application of the OECD Eutrophication Modeling Approach to Lake Ray Hubbard, Texas," *Journ. AWWA*

Nutrient Aquatic Chemistry & Availability

- "Availability of Phosphorus to Phytoplankton and its Implications for Phosphorus Management Strategies," In: Phosphorus Management Strategies for Lakes, Ann Arbor Science Publishers
- "Phosphorus Availability in Particulate Materials Transported by Urban Runoff," *Journ. Water Pollut. Control Fed.*
- "Nitrogen Availability in Urban Runoff," *Journ. Water Pollut. Control Fed.*
- "Nitrogen Fixation in Lake Mendota, Madison, Wisconsin," *Limnol. & Oceanogr.*
- "A Phosphorus Residence Time Model: Theory and Application," *Journ. Water Res*
- "Nutrient Loading from a Separate Storm Sewer in Madison, Wisconsin," *Journ. Water Pollut. Control Fed*
- "Leaves as a Source of Phosphorus," *Environ. Sci. & Technol.*
- "Recent Sedimentary History of Lake Mendota, Wisconsin," *Environ. Sci. & Technol.*
- "Oxygenation of Lake Sediments," *Air & Water Pollut.*
- "Denitrification as a Nitrogen Sink in Lake Mendota, Wis.," *Environ. Sci. & Technol.*
- "Indirect Reuse of Domestic Wastewater for Recreational Lakes: Evaluation of the Sanitary Quality of the Yellowhouse Canyon Lakes, Lubbock, Texas," Proc. AWRA Symposium: Water Supply and Water Reuse
- "Significance of Oxic vs Anoxic Conditions for Lake Mendota Sediment Phosphorus Release," Proc. UNESCO-SIL International Symposium on Interactions between Sediments and Fresh Water, Amsterdam,
- "Role of Aquatic Plant Nutrients in Causing Sediment Oxygen Demand Part I – Origin of Rapid Sediment Oxygen Demand,"
- "Role of Aquatic Plant Nutrients in Causing Sediment Oxygen Demand Part II – Sediment Oxygen Demand,"
- "Role of Aquatic Plant Nutrients in Causing Sediment Oxygen Demand Part III – Sediment Toxicity,"

Treatment of Domestic Wastewaters for Nutrient Removal

- "Nutrient Removal from Secondary Effluent by Alum Flocculation and Lime Precipitation," *Air & Water Pollut.*

SJR Delta Nutrient Issues and Related Water Quality Issues

- "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,"
- "Supplement to Synthesis Report on the Low-DO Problem in the SJR DWSC," and many other reports on the low DO problem in the SJR low DO situation
- "Delta Nutrient Water Quality Modeling Workshop — Background Information," Report of G. Fred Lee & Associates, El Macero, CA, September (2007)
- "Synopsis of CWEMF Delta Nutrient Water Quality Modeling Workshop – March 25,

2008, Sacramento, CA, the CWEMF website contains the power point presentations of the presenters

- “Comments on September 19, 2008 Delta Vision Task Force Meeting Discussion of Nutrient-Related Water Quality Problems in the Delta,”
- “Overview—Sacramento/San Joaquin Delta Water Quality,” Presented at CA/NV AWWA Fall Conference,
- “Water Quality Issues of Irrigated Agricultural Runoff/Discharges—San Joaquin River, Central Valley, California,” Presented at Agriculture and the Environment - 2007 Conference, Central Coast Agricultural Water Quality Coalition
- “Nutrient-Related Water Quality Concerns in the Sacramento and San Joaquin Rivers and Delta”
- Lee, G. F. and Jones-Lee, A., “Overview of Sacramento-San Joaquin River Delta Water Quality Issues”
- “Agriculture-Related Water Quality Problems in the San Joaquin River,” Proceedings of 2006 International Conference on The Future of Agriculture: Science, Stewardship, and Sustainability
- "Update on the Understanding of the Low-DO Problem in the San Joaquin River Deep Water Ship Channel," IEP Newsletter
- “Managing Excessive Algal Caused Oxygen Demand in the San Joaquin River Deep Water Ship Channel,” Proc. 7th IWA International Conference on Diffuse Pollution and Basin Management, Dublin, Ireland
- “Managing Nutrient (N & P) Water Quality Impacts in the Central Valley, CA,” [Excerpts from: Lee, G. F. and Jones-Lee, A., “Review of Management Practices for Controlling the Water Quality Impacts of Potential Pollutants in Irrigated Agriculture Stormwater Runoff and Tailwater Discharges,” California Water Institute Report
- “An Integrated Approach for TMDL Development for Agricultural Stormwater Runoff, Tailwater Releases, and Subsurface Drain Water,” Proc. US Committee for Irrigation and Drainage Conference on Helping Agriculture Adjust to TMDLs,
- “Need for SJR DWSC WQO TMDL DO Target Review”
- “Water Quality Issues That Could Influence Aquatic Life Resources of the Delta”
- “Synopsis of G. Fred Lee and Anne Jones-Lee's Work on Domestic Water Supply Water Quality, and TOC Issues in the Sacramento/San Joaquin River Delta”
- “A Proposal for Assessing Algal-Available Phosphorus Loads in Runoff from Irrigated Agriculture in the Central Valley of California”
- “Proposed Regionalization of Nutrient Criteria Development within the Central Valley of California,” Submitted to the US EPA RTAG Nutrient Criteria Program
- “Comments on the Adequacy of C. Dahm’s Discussion of Delta Eutrophication Issues & Delta N/P Ratios as a Cause of Adverse Impact on Delta Fish,” Comments to Delta Stewardship Council
- “Experience in Reviewing Delta Water Quality Issues”
- “Background Information on SJR Upstream Oxygen Demand Control Issues,” Prepared for San Joaquin River Technical Work Group
- “Discussion of Water Quality Issues That Should Be Considered in Evaluating the Potential Impact of Delta Water Diversions/Manipulations on Chemical Pollutants on Aquatic Life Resources of the Delta”

- “Review of Need for Modeling of the Impact of Altered Flow through and around the Sacramento San Joaquin Delta on Delta Water Quality Issues,” and “Summary: Water Quality Modeling Associated with Altered Sacramento River Flows in & around the Delta,” Report to CWEMF Stormwater Committee
- “Delta Nutrient-Related Water Quality Problems,” Presented at CALFED Science Conference

Impacts of Eutrophication on Fisheries

- “Effects of Eutrophication on Fisheries, *Reviews in Aquatic Sciences*
- “Additional Information on Impact of Waterbody Fertilization on Fish Production”