Comments on Water Environment & Technology Article,
"Algae Wars: Is Dual Nutrient Control Necessary?"[1]

G. Fred Lee, PhD, PE, BCEE. F.ASCE and Anne Jones-Lee, PhD
G. Fred Lee & Associates
El Macero, CA
530-753-9630 gfredlee@aol.com www.gfredlee.com
July 2011

The May (2011) issue of Water Environment & Technology (WE&T) carried an article by J. Palley entitled, "Algae Wars: Is Dual Nutrient Control Necessary?" that discussed a number of issues related to the control of excessive algal growths in waters. The Palley article states, "*Algae wars, Is dual nutrient control necessary to curb algal blooms? Since the 1970s, the conventional wisdom has been that phosphorus, not nitrogen, controls blooms of freshwater algae. But new research suggests that wastewater managers may now have to worry about the levels of both nutrients in their effluent if they wish to avoid triggering toxic algal blooms. Although controversy over dual nutrient control still reigns in some scientific quarters, regulatory agencies across the globe are moving to control loading of both nitrogen and phosphorus to sensitive waterbodies.*" The focus of Palley's article was whether or not it was necessary to restrict both nitrogen and phosphorus discharges to waterbodies in order to control excessive algal growth; the article summarized statements by individuals who have apparently worked on this issue.

The following comments address the adequacy and reliability of the Palley article. The author of these comments (Dr. G. Fred Lee) has been involved in the investigation of nutrient control and the effects of nutrient control measures on eutrophication-related water quality since the early 1960s. He has published extensively on his findings; many of those writings are available on his website (www.gfredlee.com) in the "Excessive Fertilization" section (http://www.gfredlee.com/pexfert2.htm). In the documents cited below, he and Dr. Jones-Lee have discussed impacts of nutrients on eutrophication-related water quality in regard to nutrient criteria; the US EPA has adopted the position of requiring regulation of both nitrogen and phosphorus in the state of Florida.

> Lee, G. F., and Jones-Lee, A., "Unreliability of US EPA-Proposed Florida Numeric Nutrient Criteria/Standards," PowerPoint slides of Invited Presentation at Meeting of Association of American Plant Food Control Officials, Portland, Oregon, August 3 (2010). http://www.gfredlee.com/Nutrients/FloridaNutrientCriteria-sli.pdf
>
> 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
>
> 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).

[1] Palley, J., "Algae Wars: Is Dual Nutrient Control Necessary to Curb Algal Blooms?" WE&T 23(5):15-16,18,20, May (2011).

http://www.gfredlee.com/Nutrients/EPA_Empirical_CritDevel.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

As discussed in those cited reviews/comments, there is substantial literature that documents the findings that for many and varied waterbodies there is an underlying and quantified relationship between the normalized phosphorus load to lakes and impoundments and the planktonic algal biomass that develops in the waterbody. The essential normalizing factor is rooted in the waterbody's mean depth and hydraulic residence time. That finding was developed and verified through the study of hundreds of waterbodies in the Organization for Economic Cooperation and Development (OECD) international eutrophication studies and in follow on-studies. The reports/papers cited below provide additional information on the results of the OECD and post-OECD studies on the relationship between the normalized P load and the planktonic algal chlorophyll that develops in a waterbody.

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

Lee, G. F. and Jones-Lee, A., "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, August (2001). (Published in part in Symposium Proceedings (Lee and Jones-Lee, 2004) [http://www.gfredlee.com/Nutrients/P_Runoff_Ag_ACS.pdf])

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

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

One of the most important elements of that body of work in terms of control of excessive fertilization of lakes and reservoirs was the explicit investigation and verification of the ability of the load–response relationships to quantitatively predict changes in planktonic algal growth in response to an alteration in phosphorus load. This is a key element that is lacking in other approaches to nutrient control. As described in the paper cited below, using data from before and after P load alterations Rast et al. (1983) compared measured changes in eutrophication-related water quality of waterbodies with that predicted based on the US OECD eutrophication modeling approach. They found that for those waterbodies to which the phosphorus load was reduced, the planktonic algal chlorophyll decreased in accord with the predictions of the US OECD normalized P load–response models.

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

Sonzoni et al. (cited below) found that planktonic algal growth a waterbody comes to an equilibrium with an alteration in P load within a period of about three times the phosphorus residence time of the waterbody.

Sonzogni, W. C., Uttormark, P. C., and Lee, G. F., "A Phosphorus Residence Time Model: Theory and Application," Journ. Water Res. 10:429-435 (1976). http://www.gfredlee.com/Nutrients/P-ResidenceTime.pdf

The phosphorus residence time is equivalent to the total mass of phosphorus in a waterbody's water column divided by the annual phosphorus load. The phosphorus residence time of a waterbody is much shorter than the hydraulic residence time (filling time) of the waterbody. For example for Lake Michigan the hydraulic residence time is about 100 yrs while the phosphorus residence time is about 6 yrs. For many waterbodies the phosphorus residence time is about 1 yr and will adjust to the new phosphorus load within a few years.

The Palley article failed to discuss the substantial literature that discusses the findings on the improvements in eutrophication-related water quality of receiving waters that have been achieved by treating domestic wastewaters for phosphorus removal, without treating for nitrogen removal. Palley's article was cited by Hwang (2011), retired branch manager of wastewater treatment for the city of Saskatoon, Saskatoon, SK, who described in a letter to the WEF (http://www.wef.org/publications/page_wet.aspx?id=10605&page=ca&section=Letters) that the removal of N and P from that city's domestic wastewater effluent improved the receiving water quality with respect to excessive aquatic plant growth. Hwang, however, failed to evaluate whether phosphorus control in the domestic wastewater effluent alone would have yielded the same improvement in the eutrophication-related water quality of the receiving water.

The California Water Environmental Modeling Forum (CWEMF) develops peer reviews of modeling approaches and develops workshops on water modeling issues; Dr. Lee has served for several years as a member of the CWEMF steering committee. With Dr. Jones-Lee he developed a workshop for the CWEMF entitled, "Overview of Delta Nutrient Water Quality Problems: Nutrient Load - Water Quality Impact Modeling," that 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] (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

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., "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

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 provided 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, and in the Lee and Jones-Lee workshop presentation, backup information, and papers referenced in their presentations, it has been well-established that reducing the phosphorus loads and in-waterbody concentrations effects reductions in the phytoplankton biomass in Delta waters. This occurs even in situations in which the available phosphorus concentrations in the waterbody remain surplus compared to growth-rate-limiting concentrations.

Also key to developing a reliable nutrient management program for a waterbody is an assessment of the load of algal-available phosphorus to the waterbody. Numerous studies have found that inorganic, particulate phosphorus is largely unavailable to support algal growth. A review of this issue was presented in the publication cited below as well as in several of the papers and reports previously cited in these comments.

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

Construction of settling basins to trap inorganic phosphorus derived from erosion of agricultural lands, especially the phosphorus in high-flow runoff, will be very costly but will not likely be effective in controlling excessive fertilization of waterbodies.

An issue of concern for many waterbodies is the impact of light-limitation on phytoplankton biomass. It was found in the post-OECD studies that waterbodies containing substantial inorganic turbidity and/or color will develop phytoplankton algal biomass as expected based on normalized P loading, but at a slower rate. It was found if a waterbody's Secchi depth was less than about 1 foot the waterbody would develop less planktonic algal biomass during the summer than the typical OECD/post OECD waterbodies. Similarly, colder waterbodies develop planktonic algal biomass as would be expected based on normalized P load, in the warmer summer months.

Overall, as discussed in our writings, before a discharger subject to nutrient control is required to implement the much more costly nitrogen control, the impact of phosphorus control alone should be evaluated. This approach will often provide the most cost-effective approach for managing excessive fertilization of waterbodies.