Comments on the Unreliability of Using Sediment Chemical Concentrations for Evaluating Cause of Sediment Toxicity and Altered Benthic Organism Assemblages in San Diego Bay Sediments

Submitted by
G. Fred Lee, PhD, BCEE, F.ASCE & Anne Jones-Lee, PhD
G. Fred Lee & Associates
El Macero, California
gfredlee@aol.com www.gfredlee.com
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The San Diego Regional Water Quality Control Board (SDRWQCB) contracted with the Aquatic Science Center Oakland, CA to investigate the relationship between the concentrations of selected chemicals in San Diego Bay sediments and sediment toxicity and altered benthic organism assemblages. Thompson et al. of that Center produced the following report on their findings:

> Thompson, B., Melwani, A.R., and Hunt, J.A., "Estimated Sediment Contaminant Concentrations Associated with Biological Impacts at San Diego Bay Clean-up Sites," SWRCB Agreement No. 08-194-190, Contribution No. 584, Aquatic Science Center, Oakland, CA (2009).
> http://www.aquaticsciencecenter.org/ASC_SanDiegoReport_Final.pdf

According to the Executive Summary of that report,
"*The objectives of this study were to: 1) identify contaminants that may be adversely impacting biological resources (benthic community, sediment toxicity) in San Diego Bay and, 2) estimate statistical impact limits for sediment contaminants that may be used for future sediment clean-up efforts.*"

"*The analyses detailed in this report suggested that biological impacts in San Diego Bay are probably associated with mixtures of sediment contaminants at several spatial scales. Most of the samples contained multiple contaminants that were significantly correlated with the biological indicators. Multivariate analysis showed that most contaminants covaried, and that the covarying sediment mixtures were usually significantly associated with benthic and/or toxic impacts. There was no evidence that any individual contaminant may be responsible for biological impacts.*"

* * *

Impact limits (confidence and prediction limits) for individual contaminants were estimated from pools of samples that were previously assessed as impacted or un-impacted by the SQO assessments. The results presented include sets of numerical impact limits for each contaminant that will provide a range of options for future sediment contamination clean-up efforts. The options include consideration of the spatial scale at which future clean-up levels might be applied; whether the limits are based on the impacted or un-impacted samples; the statistical probability level at which clean-up might be evaluated; and the number of future samples that could be used to assess clean-up progress and success."

"Other published sediment guidelines and threshold values are included for guidance and context in the selection of appropriate calculated impact limits."

Thompson et al. used statistical correlations and the co-occurrence-based "Effect Range" "Sediment Quality Guidelines" (SQGs) to develop their findings, which could result in the establishment of cleanup objectives for "contaminated" sediments. However, as discussed below, owing to the technical invalid approaches used in that investigation, implementation of clean-up objectives established pursuant to that study's findings could result in the expenditure of many millions of dollars by potentially named responsible parties (Southwest Marine shipyards, NASSCO shipyards, and city of San Diego) for the remediation of "contaminated" sediments without a reasonable expectation of improved water/sediment quality or of the elimination of a major cause of sediment toxicity.

Based on our more than four decades of professional work investigating the relationships between the concentrations of chemical contaminants in aquatic sediments and aquatic life toxicity, the methodology used by Thompson et al. is not technically valid for identifying the cause of sediment toxicity. Statistical correlations of the type used by Thompson et al. and ERL/ERM value exceedances should never be used as a basis for establishing sediment cleanup objectives.

Thompson et al. stated:
"*Since sediment contaminant mixtures were always associated with biological impacts, clean-up efforts will also need to consider how to assess remediation of sediment mixtures. Although there are currently no widely used clean-up levels for sediment contamination mixtures, impact limits were calculated for three mixture indicators. These mixture indicator limits could be used, along with individual contaminant limits, to assure that all mixture components are being reduced by the applied clean-up and remediation strategies.*

"The results presented in this report should not be interpreted as showing cause and effect between contaminants and biological impacts. Only a limited number of contaminants (10) were included in the analyses, and many other contaminants probably exist in San Diego Bay (e.g. pyretheroids, PBDEs, etc.), that may also contribute to biological effects in the Bay. The analyses were based on associations within the existing data, and while the results often showed statistical significance, conclusions about specific causes of observed biological impacts should not be made. However, the analytical methods used and the numerical limits presented are well-founded and represent the most rigorous values that can be derived at this time.

Ultimately, there are no correct or 'right' limits to select. The choice will likely be determined during negotiations between regulators and stakeholders, and this report is intended to provide the necessary technical information to facilitate these discussions."

That statement is an admission by Thompson et al. that their approach for evaluating sediment toxicity is not reliable for identifying the cause of sediment toxicity, which invalidates their recommendation that that approach can be used by regulatory agencies to establish sediment cleanup objectives. Their claim that their technically unreliable methods and "numerical limits" are "*well-founded and represent the most rigorous values that can be derived at this time*." does

not reflect an understanding of the fundamentals of aqueous environmental chemistry and toxicology or of the technical literature on how to properly and reliably identify the cause(s) of sediment toxicity. Rather, it reflects a focus on administrative expedience.

Basis for Comments

In the 1970s Dr. G. Fred Lee conducted an approximately $1-million, five-year study of sediment-associated contaminants for the US Army Corps of Engineers Dredged Material Research Program. It involved collecting aquatic sediments from about 100 sites across the US and testing them for about 30 parameters, including organochlorine legacy pesticides (DDT), PCBs, heavy metals, several other potential pollutants, and aquatic life toxicity. The results of that study were published by the Corps of Engineers as a 2-part, 1,500 page report:

> Lee, G. F., Jones, R. A., Saleh, F. Y., Mariani, G. M., Homer, D. H., Butler, J. S. and Bandyopadhyay, P., "Evaluation of the Elutriate Test as a Method of Predicting Contaminant Release during Open Water Disposal of Dredged Sediment and Environmental Impact of Open Water Dredged Materials Disposal, Vol. II: Data Report," Technical Report D-78-45, US Army Engineer Waterway Experiment Station, Vicksburg, MS, 1186 pp., August (1978).
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> Jones, R. A. and Lee, G. F., "Evaluation of the Elutriate Test as a Method of Predicting Contaminant Release during Open Water Disposal of Dredged Sediment and Environmental Impact of Open Water Dredged Material Disposal, Vol. I: Discussion," Tech Report D-78-45, US Army Engineer Waterway Experiment Station, Vicksburg, MS, August (1978).

Numerous papers and reports that Lee and his colleagues developed on those and subsequent studies are available on Lee's website in the Contaminated Sediments section: [http://www.gfredlee.com/psedqual2.htm#dredge].

Those Corps of Engineers studies served as the technical basis for the past and current regulatory approach used by the US EPA and the Corps of Engineers for regulating dredged sediment disposal. While the studies showed that many of the US waterway sediments studied contained high concentrations of many potential pollutants such as heavy metals, pesticides, and PCBs, those chemicals were not in toxic forms. The toxicity caused in the laboratory toxicity tests of those sediments was found to be due to ammonia derived from the accumulation of particulate organic nitrogen that decomposed to ammonia. Long and Morgan used the Lee et al. database in developing the so-called sediment quality guidelines (ERLs and ERMs) but failed to include information on the presence of ammonia in the sediments that has been found to be the most likely cause of the sediment toxicity found in those studies.

In the early 1990s, on behalf of the Port of San Diego, Lee and Jones-Lee conducted a study of the water quality significance of the copper in sediments near the National City Marine Terminal that had been spilled in the transfer of copper ore concentrate from shore to a ship. That study was reported in:

> Jones-Lee, A., and Lee, G. F., "Evaluation of the Water Quality Significance of Copper in San Diego Bay Sediments," Division Environmental Chemistry, American Chemical Society meeting, extended abstract, Washington, DC, pp. 107-108, March (1994).

http://www.gfredlee.com/Sediment/sdcu1_abs.htm

Some of the sediments in that area contained about 50,000 mg Cu/kg sediments. Using the statistical correlations and the ERM guidelines, those sediments would be predicted to be highly toxic. However, testing with nine different organisms showed that the copper in the sediments from the spill, as well as the copper from other sources and other chemicals, was not toxic.

Unreliability of ERLs and ERMs as a Measure of Sediment Toxicity

Lee and Jones-Lee have published extensively on the lack of technical validity of the "Long and Morgan" ERLs-based sediment quality guidelines, and on essential technical components for making reliable assessments of sediment toxicity and impacts. Their publications on those and related issues are available on their website, www.gfredlee.com in the Contaminated Sediment section at http://www.gfredlee.com/psedqual2.htm#criteria. Of particular relevance to this matter are the following:

Lee, G. F. and Jones-Lee, A., "Appropriate Incorporation of Chemical Information in a Best Professional Judgment 'Triad' Weight of Evidence Evaluation of Sediment Quality," Presented at the 2002 Fifth International Symposium on Sediment Quality Assessment (SQA5), IN: Munawar, M. (ed.), Aquatic Ecosystem Health and Management 7(3):351-356 (2004).
http://www.gfredlee.com/Sediment/BPJWOEpaper.pdf

Jones-Lee, A. and Lee, G. F., "Unreliability of Co-Occurrence-Based Sediment Quality Guidelines for Contaminated Sediment Quality Evaluation at Superfund/Hazardous Chemical Sites," Journ. Remediation 15(2):19-34 (2005).
http://www.gfredlee.com/Sediment/SQGSuperfund2.pdf

Lee, G. F., and Jones-Lee, A. "Unreliability of Sediment Co-Occurrence-Based Approaches for Evaluating Aquatic Sediment Quality," Excerpts from Lee, G. F. and Jones-Lee, A., "Organochlorine Pesticide, PCB and Dioxin/Furan Excessive Bioaccumulation Management Guidance," California Water Institute Report TP 02-06 to the California Water Resources Control Board/Central Valley Regional Water Quality Control Board, 170 pp, California State University Fresno, Fresno, CA, December 2002, updated August (2003). http://www.gfredlee.com/Sediment/UnrelSedCooccur.pdf

Lee, G. F., Jones-Lee, A., "Appropriate Incorporation of Chemical Information in a Best Professional Judgment 'Triad' Weight of Evidence Evaluation of Sediment Quality," Poster presentation at 5th International Symposium on Sediment Quality Assessment, Aquatic Ecosystem Health and Management Society, Chicago, IL, October (2002).
http://www.gfredlee.com/Sediment/BPJ_Poster.pdf

Lee, G. F. and Jones-Lee, A., "Evaluation of the Water Quality Significance of the Chemical Constituents in Aquatic Sediments: Coupling Sediment Quality Evaluation Results to Significant Water Quality Impacts," Proc. Water Environment Federation National Annual Conference, Dallas, TX, October (1996).
http://www.gfredlee.com/Sediment/wef_seda.htm

Lee, G.F, and Jones-Lee, A., "Developing TMDLs for Organochlorine Pesticides and PCBs," Presented at the American Chemical Society Environmental Chemistry Division national meeting in San Diego, California, April (2001). http://www.gfredlee.com/Runoff/sandiego_030801.pdf

Dr. Tom O'Connor of NOAA who headed the NOAA Status and Trends program has also published the following discussion:
O'Connor, T. P., "The Sediment Quality Guideline, ERL, Is Not a Chemical Concentration at the Threshold of Sediment Toxicity," Mar. Poll. Bull. 49:383-385 (2004). http://www.gfredlee.com/Sediment/oconnor.pdf

As discussed in those cited works, "ERLs/ERMs" are technically unsound and wholly unjustifiable for addressing issues of sediment toxicity, especially associated with organochlorine legacy pesticides and PCBs. With few exceptions these chemicals are not in toxic forms in sediment. Further, they are of water quality concern not because of their aquatic life "toxicity" but rather because they bioaccumulate in edible aquatic organisms; people who eat fish contaminated by these chemicals face an increased cancer risk. Ed Long of "Long and Morgan" has stated specifically that the ERLs should not be used for these chemicals. There are no sediment quality guidelines to address these issues; the SWRCB staff is trying to develop administratively expedient guidelines for these chemicals.

Lee and Jones-Lee have closely followed the SWRCB's development of SQOs, and has commented on the strengths and weaknesses of the technical elements of SQOs in papers and reports including the following:

Lee, G. F., and Jones-Lee, A., "Development of Sediment Quality Objectives for California" PowerPoint slides presented at the American Water Resources Association national conference San Diego, CA November (2003) http://www.gfredlee.com/Sediment/SedimentQualityObjectives.pdf

Lee, G. F. and Jones-Lee, A., "Development of Sediment Quality Objectives for California," Presented at the American Water Resources Association national conference, San Diego, CA, November (2003). http://www.gfredlee.com/Sediment/sediment-SQO-paperSD.pdf

Several other sets of comments focus on the unreliability of the SWRCB SQOs.

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, 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 the cited comments, the SWRCB SQO-development studies resoundingly confirmed what Lee and his associates established in their 1970s Corps of Engineers dredged sediment study, i.e., that there is no relationship between the total concentration of heavy metals (individually or collectively), organochlorine legacy pesticides, PCBs, or many other constituents and the toxicity of the subject sediment. The SWRCB staff abandoned the ERL and ERM approach to sediment quality guidelines owing to their intrinsic unreliability, and opted for an integrated assessment of concentration of selected chemicals, measured toxicity, and alterations in benthic organism assemblages for the evaluation of sediment quality.

The cited comments of the authors also address issues of the unreliability of using statistics-based chemical concentration approaches for classifying sediment quality. The SWRCB staff recognized that such SQO chemical concentration-based approaches could be expected to lead to incorrect/unreliable assessments of the role of subject chemicals in causing sediment toxicity. In an attempt to correct for that fundamental deficiency, the staff provided guidance for conducting toxicity identification evaluations (TIEs) to identify the cause(s) of toxicity measured in the toxicity tests. Unfortunately, much of that guidance is also not technically valid and following it could readily result in misidentification of constituent(s) responsible for the sediment toxicity.

There are several other significant technical problems with the SWRCB SQOs, including their failure to incorporate sulfide as a potential toxicant, and their ignoring the impact of rapid-acting sediment oxygen demand on benthic organism assemblages. The current SQOs fail to consider that significant alterations of benthic organism assemblages can occur without their being identified by those SQOs due to ferrous iron and sulfides in sediments that exert an oxygen demand upon suspension in the water column. These issues are discussed in several reports developed by the authors that are on their website as,

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

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

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

With respect to the use of use of statistical correlations as a substitute for cause and effect chemical TIEs/biologically based studies this approach can readily lead to incorrect identify the toxicity of heavy metals, organic chlorine legacy pesticides, PCBs since this approach ignores the aquatic chemistry of these chemicals to lead to non toxic forms in sediments. Statistical

"relationships" can be developed that have little or no capability to reliably predict changes in sediment toxicity related water quality characteristics that would result from changes in chemical concentrations in sediments. Such a demonstration is of paramount importance for the development of sediment cleanup objectives. Any statistical relationship between chemical concentrations in sediments and sediment toxicity must be solidly grounded in fundamental mechanisms (cause-effect) that influence how a chemical in sediments could impact sediment toxicity. Without such a foundation, the statistical relationship is simply game playing.

The unreliability of statistical correlations to reliable establish true cause and effect relationships is discussed in,

> Siegfried, T., "Odds Are, It's Wrong: Science Fails to Face the Shortcomings of Statistics," Feature in Science News 177(7):26 March 27 (2010).
> http://www.sciencenews.org/view/feature/id/57091/title/Odds_Are,_Its_Wrong

Information on the role of PCBs and other bioaccumulatable chemicals in aquatic sediments in impacting a waterbodies water quality is available in,

> Lee, G. F., and Jones-Lee, A., "PCBs as an Unlikely Cause of Urban Aquatic Sediment Toxicity: Colorado Lagoon Sediment TMDL," Report of G. Fred Lee & Associates, El Macero, CA, December 3 (2010).
> http://www.gfredlee.com/Sediment/PCBs-SedToxicity.pdf

Urban Pesticides as a Cause of Sediment Toxicity

Based on findings in similar situations, to the extent that there is aquatic life toxicity in urban waterbody sediments it is most likely due to pyrethroid-based pesticides derived from the use of such pesticides in residentialcommercial properties in the waterbodies watershed. Lee has had extensive experience in water quality impacts of pyrethroid pesticides; his work was the first to find that these types of pesticides were a cause of part of the aquatic life toxicity in the tributaries of Upper Newport Bay, CA. On behalf of the Santa Ana Regional Water Quality Control Board he and his colleagues conducted a major study of aquatic life toxicity in those tributaries during stormwater runoff events and developed several reports discussing the findings, including:

> Lee, G. F. and Taylor, S., "Results of Aquatic Toxicity Testing Conducted During 1997-2000 within the Upper Newport Bay Orange County, CA Watershed," Report of G. Fred Lee & Associates, El Macero, CA (2001).
> http://www.gfredlee.com/Watersheds/295-319-tox-paper.pdf

Lee's Stormwater Runoff Water Quality Newsletters 1-1, 2-1, 3-5, 3-6, 6-3, 6-4, 7-6/7, 8-1/2, 9-3, 9-4, 9-6, 9-7, 9-8, 10-3, 10-8, 10-12, 11-4, 11-7/8, 12-4, 12-7/8, 13-1, 13-2 available at, http://www.gfredlee.com/newsindex.htm provides discussion of many aspects and issues of aquatic life toxicity in urban stormwater runoff. Since completing the original studies in the 1990s he and others have found that pyrethroid pesticides are a common cause of aquatic life toxicity in water and sediments of urban waterbodies. They are likely to be the cause of aquatic life toxicity in San Diego Bay sediments, as well, and this toxicity will likely continue for many years to come since the pesticide regulatory agencies have indicated that it will likely be many years before the pyrethroid based pesticides are regulated to control aquatic life toxicity in urban stormwater runoff and waterbody sediments. Since the PCBs, organochlorine legacy pesticides and heavy metals in the sediments of San Diego Bay sediment are unlikely to be contributing to

toxicity of those sediments, and since pyrethroid pesticides and other real potential causes of toxicity are not being addressed in a reliable manner, in the remediation of San Diego Bay sediments, the dredging of the bay sediments to remove these pollutants will not address, much less remedy, the problem of sediment toxicity.

Recommended Approach

The San Diego Regional Water Quality Control Board should abandon efforts to develop San Diego Bay sediment remediation goals based on statistical correlations and ERLs/ERMs exceedances. Reliably conceived and conducted sediment toxicity studies should be conducted to determine whether the toxicity in the sediments of concern is being caused by pyrethroid-based pesticides. If a substantial amount of the toxicity being experienced is found to be due to causes other than pyrethroid-based pesticides, properly conducted toxicity identification evaluations (TIEs) should be conducted to reliably identify and verify the cause(s) of the toxicity. Based on that information, the Regional Board should develop site-specific sediment remediation goals, carefully determine the current significant source(s) of the toxicants that are accumulating in the Bay sediments, and direct control efforts toward those sources. Information on Dr. Lee's expertise and experience is appended to these comments.

Summary Resume – G. Fred Lee, PhD, PE, BCEE, F.ASCE

American Academy of Environmental Engineers Board Certified Environmental Engineer

Dr. G. Fred Lee is president of G. Fred Lee and Associates, an environmental quality consulting firm that specializes in addressing advanced technical aspects of water supply water quality, water and wastewater treatment, water pollution control, and solid and hazardous waste impact evaluation and management. Drs. G. Fred Lee and Anne Jones-Lee are the principals of the firm. After earning his B.A. degree from San Jose State College in 1955, Dr. Lee earned his Master of Science in Public Health degree from the University of North Carolina in 1957 focusing on water quality, and his PhD degree from Harvard University in 1960 in Environmental Engineering. For 30 years, Dr. Lee held university graduate faculty positions in civil/environmental engineering at several US universities. During that time he taught graduate-level courses in environmental engineering and environmental sciences, conducted over $5-million in research, and published more than 475 professional papers and reports. Active as a part-time consultant during his university teaching and research career, Dr. Lee has been a full-time consultant since retiring from university teaching and research in 1989. One of his areas of specialization is the development of technically valid water quality investigations and cost-effective pollutant control programs to protect the designated beneficial uses of waterbodies without significant unnecessary expenditures for constituent control. Over the past 20 years in private consulting, he has developed another 600 professional papers and reports on his work, and has for the past 13 years published the "Stormwater Runoff Water Quality Newsletter." Drs. G. Fred Lee and Anne Jones-Lee have established a website, www.gfredlee.com, where they list and make available their recent papers, reports, and Newsletter. Additional information on Dr. G. Fred Lee's professional activities is available upon request.

CONTACT: 27298 E. El Macero Dr., El Macero, CA 95618 email: gfredlee@aol.com
phone: (530)753-9630 web site: http://www.gfredlee.com

DATE & PLACE OF BIRTH: July 27, 1933; Delano, California, USA

EDUCATION

Ph.D.	Environmental Engineering & Environmental Science, Harvard University, Cambridge, MA, 1960
M.S.P.H.	Environmental Science-Environmental Chemistry, School of Public Health, University of North Carolina, Chapel Hill, NC, 1957
B.A.	Environmental Health Science, San Jose State University, San Jose, CA, 1955

ACADEMIC AND PROFESSIONAL EXPERIENCE
Current Position: Consultant; President, G. Fred Lee & Associates 1989 – present

Previous Positions:

- Distinguished Professor, Civil and Env. Engr, New Jersey Inst Technol, Newark, NJ 1984-89
- Senior Consulting Engineer, EBASCO-Envirosphere, Lyndhurst, NJ, (part-time) 1988-89
- Coordinator, Estuarine and Marine Water Quality Management Program, NJ Marine Sciences Consortium Sea Grant Program 1986-1988
- Director, Site Assessment and Remedial Action Division, Center for Research in Hazardous & Toxic Substances, NJIT et al., Newark, NJ 1984-1987
- Professor, Environmental Engineering, Colorado State University 1978-1982
- Professor, Environmental Engineering & Sciences; Director, Center for Environmental Studies, University of Texas at Dallas 1973-1978
- Professor of Water Chemistry, Department of Civil & Environmental Engineering, University of Wisconsin-Madison 1961-1973

Registered Professional Engineer, State of Texas, Registration No. 39906
Engineers Board Certified Environmental Engineer Certificate No. 0701

Dr. Lee served as the AAEE Chief Examiner for Board Certification for Northern California from 1989 to 2010.

PUBLICATIONS & AREAS OF ACTIVITY: Published over 1100 professional papers, chapters in books, professional reports, and similar materials. The topics covered include:

- sources, significance, fate and the development of control programs for chemicals in aquatic and terrestrial systems;
- analytical methods for chemical contaminants in fresh and marine waters;
- landfills and groundwater quality protection issues;
- impact of landfills on public health and environment;
- environmental impact & management of wastewater discharges including municipal, mining, electric generating station, domestic & industrial wastes, paper & steel mill, refinery;
- stormwater runoff water quality evaluation;
- stormwater BMP development for urban areas, highways and agricultural areas;
- eutrophication-excessive fertilization – causes and control;
- impact of land disposal municipal & industrial wastes on groundwater & surface water

quality;
- environmental impact of dredging and dredged material disposal;
- water quality modeling;
- hazard assessment for new and existing chemicals;
- water quality and sediment criteria and standards;
- water supply water quality;
- assessment of actual impact of chemical contaminants on water quality.

LECTURES: Presented over 860 lectures at professional society meetings, universities, and to professional and public groups.

GRANTS AND AWARDS: Principal investigator for over $8 million of contract and grant research in the water quality and solid and hazardous waste management fields.

KEY PROFESSIONAL SOCIETY ACTIVITIES: Member: American Chemical Society, American Fisheries Society, American Society of Civil Engineers, American Water Works Association, Society of Environmental Toxicology and Chemistry, Water Environment Federation

- Reviewer, Natl. Academy of Sciences & Engineering Panel on Water Quality Criteria, 1971
- Member, Water Pollution Control Federation Sediment Water Quality Task Force, 1992-94; Water Quality Criteria Task Force, 1993
- Reviewer, American Fisheries Society-US EPA Water Quality Criteria, 1977
- Chairman, Water Pollution Control Federation Standard Methods Subcommittee, "Interpretation and Application of Bioassays," 1979-1988
- Chief Examiner, American Academy of Environmental Engineers, North Central California, 1991 – present
- Led development of California Groundwater Resources Association, 1992-1993
- Member, California EPA Comparative Risk Project Human Health Committee, 1993-1994
- Member, WEF Urban Stormwater Quality Task Force, 1994-1997
- US EPA TAG Advisor for the UCD/DOE LEHR Superfund site, 1995 – present
- US EPA TAG Advisor for the Lava Cap Mine Superfund site, 2001-2004
- PI for $2 million/yr CALFED research project on the San Joaquin River DO TMDL Program
- Member, Editorial Board, Journal Stormwater, 2001 – present
- Member, Editorial Board, Journal Remediation, 1999 – present
- Member, CVRWQCB Ag Waiver Technical Issues Committee, 2004 – present
- Served various times, as member editorial board of several journals including Environ. Science & Technol., Journ. Society for Environmental Toxicology & Chemistry, Journ. Ground Water, Journ. Stormwater

HONORS AND AWARDS: Elected member of the following: Sigma Xi; Delta Omega, Honorary Public Health Scholastic Society; Phi Lambda Upsilon, Honorary Chemistry Scholastic Society; Diplomate, American Academy of Environmental Engineers

- Tied for first place for best paper presented at the Fifth Annual ASTM Aquatic Toxicology meeting in Philadelphia, PA, October, 1980
- Charles B. Dudley Award - American Society for Testing and Materials award for contribution to Hazardous Solid Waste Testing, "Application of Site-Specific Hazard Assessment Testing to Solid Wastes," published 1984
- Journal AWWA paper selected by the Resources Division of the AWWA as the best paper published in the Journal during the year, 1984
- Received Certificate of Appreciation from the Corps of Engineers for work on the Dredged Material Research Program, 1978
- Tribute of Appreciation - Groundwater Resources Association of CA, September 2000
- Elected Fellow of the American Society of Civil Engineers
- Sacramento Section awarded Outstanding ASCE Life Member 2010

Additional information on Dr, Lee's qualification and experience is available on his website, www.gfredlee.com at http://www.gfredlee.com/gflinfo.htm

Announcement of American Society of Civil Engineers (ASCE) Election of Dr. G. Fred Lee as ASCE Fellow

In December 2009 Dr. G. Fred Lee was elected as an ASCE Fellow. This election recognizes Dr. Lee five decade career as a national/international leader university graduate level educator and environmental consultant. The ASCE announcement of this election is presented below.

G. FRED LEE, Ph.D., P.E., BCEE, F.ASCE, earned his Master of Science in Public Health from the University of North Carolina in 1957 and his PhD degree in environmental engineering from Harvard University in 1960. For 30 years he served on the graduate civil and environmental engineering/science faculty of several major US universities where he taught, conducted research, mentored the Masters and PhD work of 90 students, published extensively in professional journals, and actively undertook public service for the regulatory, professional, and lay communities.

In 1989 Dr. Lee retired from his academic career to focus on private consulting and public service; he is president of G. Fred Lee & Associates. Areas of emphasis include domestic water supply water quality focusing on how land use in a water supply watershed impacts water supply water quality; investigation and management of surface and groundwater quality, stormwater runoff, contaminated sediments, land surface activities that impact groundwater quality, and use of reclaimed wastewater; and investigation and management of impacts of solid and hazardous chemicals including MSW and hazardous waste landfills, Superfund, and other hazardous chemical sites.

Dr. Lee has served on the editorial boards for several professional publications, and currently serves on the editorial board for the Journals *Stormwater* and *Remediation*. Dr. Lee has long served on the American Academy of Environmental Engineers' (AAEE) examination board for AAEE professional engineer certification; until 2009 he served as Chief Examiner for Northern California in Water Supply and Wastewater and in the Hazardous Waste areas for 20 years.

Dr. Lee has published more than 1100 professional papers and reports many of which are posted on his website [www.gfredlee.com]. In addition, out of the need for greater influence of science and engineering in water quality regulation and management, he created and authors an email-based Stormwater Runoff Water Quality Newsletter which he has distributed about monthly for the past 12 years, at no-cost, to about 8,000 subscribers.

Outstanding ASCE Life Member

Dr. G. Fred Lee — G. Fred Lee & Associates

Dr. Lee has been a full-time consultant through the firm of G. Fred Lee & Associates since 1989 when he moved to El Macero, CA (near Sacramento). This firm specializes in evaluating and managing the impacts of chemicals on water quality, advanced level water supply water quality, water and waste water treatment, water pollution control, and solid and hazardous waste investigation and management. Dr. Lee has established a website, www.gfredlee.com, where he has make available over 600 papers and reports developed from his research and consulting activities. In December 2009, Dr. G. Fred Lee was elected as an ASCE Fellow. This election recognizes Dr. Lee's five-decade career as a national/international leader, university graduate-level educator, and environmental consultant.

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