G. Fred Lee & Associates

27298 E. El Macero Dr.
El Macero, California 95618-1005
Tel. (530) 753-9630 • Fax (530) 753-9956
e-mail: gfredlee@aol.com
web site: http://www.gfredlee.com

May 20, 2003

Comments on the Unreliability of the SWRCB Workplan for Developing Sediment Quality Objectives

Arthur G. Baggett, Jr., Chairman
State Water Resources Control Board

Dear Chairman Baggett:

I am following up on the discussions of the SWRCB draft Workplan for developing sediment quality objectives (SQOs). I appreciate that it is not possible to submit any additional materials for review regarding the staff's revised Workplan. Previously, I have indicated in my comments that the SWRCB staff draft workplan had proposed to follow a technically invalid approach for developing SQOs in which an attempt will be made to use concentrations of chemicals in sediments to determine violations of sediment quality objectives. Of particular concern is the specific mention in the draft Workplan of the use of Long and Morgan co-occurrence values to develop sediment quality objectives. It was this approach that caused the SWRCB's previous attempt to fail to develop SQOs.

On May 9, 2003, the SWRCB staff released its "Responses to Comments." It does not mention the fact that I had commented and provided substantial references to the technical literature on the well-known technical invalidity of chemical concentration-based approaches for regulating sediment quality. The revised Workplan also fails to address this issue. I feel that you should be aware that the current SWRCB staff's SQO Workplan as currently planned could develop unreliable SQOs.

In accord with the notice of the SQO Workplan workshop, I provided detailed comments on the March 19, 2003, Draft Sediment Quality Objectives Development Workplan. The topic of developing appropriate approaches for regulating chemical constituents in sediments is a topic that I have worked on since the 1970s in various parts of the US and specifically in California since I returned to the State in 1989, and one that I continue to be involved in nationally. As the final comments at the Sediment Quality Objectives Development Workplan workshop, you indicated that the adoption of the Sediment Quality Objectives Development Workplan could be put on the consent calendar, indicating that you thought that there were no objections to the proposed Workplan. This is a highly inappropriate interpretation of the current situation and evidently you had not read my comments and/or were provided unreliable information on this issue. I indicated on the workshop speaker card that I would answer questions on my comments. Neither the staff, you nor other Board members asked any questions, indicating that either they

had not read my comments, or understood them and would make appropriate changes in the Workplan.

Subsequent to the Workshop I received and reviewed the staff's May 9, 2003, revisions to the March 19, 2003, draft Workplan. The current Workplan suffers from essentially all of the problems that I commented on in my comments sent to the State Board on the initial draft. A copy of these comments is attached.

The key issue that the State Board and others should be cognizant of is that, as discussed in my comments, there is a fundamental problem with the Board staff's interpretation of the California Water Code Section 13393. As discussed in detail in my comments and in the references cited therein, co-occurrence-based sediment quality guidelines are fundamentally flawed, since they do not relate the concentration of a toxic available form of a constituent in sediments to its impact on the beneficial uses of the waterbody in which the sediments are located. Those who are recommending that the Board adopt this approach either do not know or do not understand the literature that exists on the impossibility of developing reliable chemical-specific numeric sediment quality objectives for constituents that are potential pollutants in sediments. This issue was understood in the 1970s, when the Corps of Engineers and the US EPA determined that it is not possible to use chemical concentrations of constituents in sediments to predict waterbody water quality beneficial use impacts associated with dredged sediment management programs. Instead, it is necessary to use approaches based on chemical impacts, such as toxicity, bioaccumulation, altered numbers and types of benthic organisms, etc.

The staff's approach for developing sediment quality objectives, as set forth in the Workplan, needs to be changed so that the development of sediment quality objectives includes focusing on developing guidance on how to evaluate, based on a best professional judgment weight-of-evidence approach, the water quality/beneficial use impairment associated with constituents in sediments. Failure to make this change will lead to failure of the sediment quality objectives that develop from this effort to be reliable in predicting impacts.

Further, and most importantly, by adopting the current sediment quality objectives development Workplan, the State Water Resources Control Board will be supporting the use of technically invalid approaches for assessing the significance of chemicals in aquatic sediments, which could be, depending on the constituent in sediments, either under protective or overprotective. This approach will lend credence to those at the State and local levels who do not understand the unreliability of this approach to use the chemically based sediment quality objectives as regulatory limits, which could cause the unnecessary expenditure of many millions of dollars in Superfund (Aquafund) sediment cleanup projects, which will have little or no impact on the beneficial uses of the waterbody in which the sediments are located. Also, in those situations where the chemical-specific numeric sediment quality objectives are under protective (such as for the bioaccumulation of hazardous chemicals such as mercury, organochlorine pesticides, PCBs, etc.), constituents in sediments that are having significant adverse impacts on the beneficial uses of the overlying waters will not be addressed. In addition, since there is substantial information on the unreliability of chemical-specific numeric sediment quality objectives as regulatory tools, the attempts to implement the objectives that develop out of this

effort will almost certainly lead to litigation, where ultimately the courts will decide whether a specific application of the SWRCB sediment quality objectives is accepted.

A continuing significant problem with the May 9, 2003, revised Workplan is the decision not to focus on bioaccumulation issues. I discussed this issue in my April 4, 2003, comments on the March 19, 2003, draft Workplan. Without question, one of the, if not the, most important impacts of many of the most significant chemicals in sediments is their bioaccumulation to excessive levels in edible organisms. This is a significant public health threat to cause cancer in people who use the fish and other aquatic life as food. Rather than being a secondary issue, it should be one of the primary issues of concern for sediment quality objectives. Again, as I discussed in my comments, the approach should be that of developing guidance on how to evaluate the potential for excessive bioaccumulation of hazardous chemicals in sediments that are a threat to those who use edible organisms from the water as food – not development of chemical-specific numeric values.

The issue that was brought up by a couple of those who made presentations at the workshop on sediment quality objectives, about integrating how the objectives are used in the regulatory processes, is extremely important. Sediment quality objectives, whether chemical-specific or narrative, are empirical. They are based on certain types of measurements. These measurements do not delineate the impairment of the beneficial uses, except possibly for excessive bioaccumulation, and even there the link between the bioavailable forms in the sediments and the concentrations in aquatic organism tissues is a site-specific issue that has to be addressed through detailed studies. The Board should require that the staff integrate the sediment quality objectives development approach with how the objectives will be used in regulating contaminated sediments, if the objectives and the regulatory process are to have credibility.

In my April 4, 2003, comments, I mentioned that, as part of developing a report ("Organochlorine Pesticide, PCB and Dioxin/Furan Excessive Bioaccumulation Management Guidance,") for the State Water Resources Control Board/CVRWQCB that was completed in December 2002, devoted to developing guidance on how to manage the excessive bioaccumulation problem that occurs in a number of California waterbodies in which the constituents that are bioaccumulating to excessive levels in edible fish are derived, at least in part (and possibly essentially completely) from aquatic sediments, I developed a review of the literature and my professional experience on this issue. I made reference to this review in my April 4, 2003, comments. I indicated in my comments that this material was available on my website. www.gfredlee.com.

Because of the importance of this issue, I am appending to these comments the section of my December 2002 SWRCB report that deals with the unreliability of co-occurrence-based sediment quality guidelines. In that section, reference is made to a conference held in October 2002 in Chicago, entitled "Aquatic Ecosystems and Public Health: Linking Chemical, Nutrient, Habitat and Pathogen Issues." This conference was organized by the international Aquatic Ecosystem Health and Management Society. As discussed, several of the invited speakers, who are internationally recognized authorities on sediment quality issues, discussed the unreliability of co-occurrence-based sediment quality guidelines in evaluating the water quality significance of chemical constituents in sediments. No one at the conference spoke in support of using co-

occurrence values (such as Long and Morgan values) as a reliable tool for regulating contaminated sediments. The conference proceedings are in press.

Subsequently, in April 2003, the US Army Corps of Engineers and the US EPA Superfund Program organized a three-day national Workshop on Environmental Stability of Chemicals in Sediments. A number of invited papers were presented at this workshop which further demonstrated the unreliability of co-occurrence-based sediment quality guidelines for regulating contaminated sediments. Further, no one spoke in support of the use of co-occurrence-based approaches. A number of individuals discussed the danger of developing this approach, since it gives regulatory agencies and others a simple, albeit unreliable, approach for regulating sediments.

It has been discussed in numerous papers in the literature, and I have discussed in my previous comments on the Workplan and in my papers and reports, that a best-professional-judgment triad weight-of-evidence approach should be used to regulate contaminated sediments. One of the speakers at the sediment chemical stability conference, Dr. C. Menzie, discussed "Using Weight of Evidence Approaches for Sediment Management." He summarized his experience in working with the Commonwealth of Massachusetts to incorporate the weight of evidence approach as a regulatory approach used in that state for regulating contaminants in sediments. California should follow a similar best professional judgment weight of evidence approach in developing its sediment quality regulatory approach.

Another issue raised at the Sediment Quality Objectives Development Workplan workshop, about a stakeholder group and scientific advisory group in which the regulated community and others knowledgeable in the topic area would be participants, and that needs to be addressed by the Board is the composition of the Scientific Steering Committee technical advisory group. This is crucial to gaining acceptance of the objectives. However, the revised Workplan has a new significant problem, where the staff has now (on page 7) limited the membership of the Scientific Steering Committee to *"A member of a key agency involved in sediment quality assessment such as U.S. EPA, USACE, NOAA or USGS."* Some of the most knowledgeable individuals on how chemicals in sediments impact aquatic life and other beneficial uses of waterbodies are not associated with a governmental agency.

Further, with respect to including agency personnel in the Scientific Steering Committee, great care must be exercised to avoid the problems that occurred in the BPTCP, where the State Board staff selected agency personnel who they knew would support their preconceived position on how to develop sediment quality objectives. Those familiar with the field nationally know that, within each agency (such as NOAA, the US EPA, the USGS), there are individuals who support the technically invalid co-occurrence approach, while others in the agency, with even greater experience and knowledge, have demonstrated that the co-occurrence-based approach is technically invalid and unreliable.

As an example of the dichotomy within agencies, the US EPA national Superfund program, in the winter 2002-2003, released its request for comments on the draft "Contaminated Sediment Remediation Guidance for Hazardous Waste Sites," in which the US EPA Superfund program has explicitly stated that co-occurrence-based sediment quality guidelines (such as Long and

Morgan values) shall not be used as regulatory guidelines. However, the US EPA Region 9 staff has used this approach to determine the cleanup objectives for organochlorine pesticides and PCBs in Upper Newport Bay and its tributaries in Orange County, California. A critical review of US EPA Region 9's approach shows that it is technically invalid and will not properly address the excessive bioaccumulation of organochlorine pesticides such as DDT and PCBs.

Because of the slow rate at which the SWRCB staff made the draft Workplan available compared to the court deadline for completion of the Workplan, it appears to be too late to correct the significant error being made by the SWRCB staff in developing this Workplan. In light of this situation it will be important that all of those concerned about developing reliable sediment quality objectives, including the DeltaKeeper, keep close watch on the development of the SQOs to work toward insuring that they are technically valid. If the same kinds of problems begin to occur again as occurred before in the BPTCP, the DeltaKeeper and others may need to go back to the court for assistance.

If you have questions on this matter please contact me.

Sincerely yours,

G. Fred Lee

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Copies to: William Jennings, DeltaKeeper
Tom Howard

Comments on March 19, 2003, Draft
Revised Workplan for the Development of Sediment Quality Objectives for Enclosed Bays and Estuaries of California

Comments Submitted by
G. Fred Lee, PhD, DEE
G. Fred Lee & Associates
27298 E. El Macero Drive, El Macero, CA 95618
Ph: (530)753-9630 Fx: (530)753-9956 Em: gfredlee@aol.com
www.gfredlee.com

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Provided below are comments on the March 19, 2003, draft Revised Workplan for the Development of Sediment Quality Objectives for Enclosed Bays and Estuaries of California.

Overall Comments

On page 4, first paragraph, beginning on the first line, it is stated, with regard to the development of Sediment Quality Objectives in the BPTCP, that, *"Insufficient funding resulted in significant delay of the program."* This statement is highly misleading and not accurate with respect to the problems with why the previous efforts by the SWRCB did not result in SQOs. The problem was inappropriate leadership of the program, where the SWRCB staff responsible for the program made up their mind early on the use of co-occurrence-based Sediment Quality Objectives. I was involved throughout this process, commenting on the inappropriateness of that approach. Copies of my comments are available from my website, www.gfredlee.com, in the Contaminated Sediment section. Any of the sets of comments listed can be obtained upon request from gfredlee@aol.com.

As discussed in comments provided by myself and others, the SWRCB's earlier attempt at Sediment Quality Objective development was doomed from the start because of the approach taken. Large amounts of funds were used in this effort to support an ill-conceived project, which at the time was predicted to produce nothing in the way of useful information. These predictions have proven to be correct.

I am concerned that the draft Workplan appears, at least in part, to be an attempt to develop chemically-based Sediment Quality Objectives. It will be very important that the SWRCB not make the same mistakes that it did in the past in trying to develop Sediment Quality Objectives, by focusing on chemical concentration-based objectives, as opposed to chemical impact objectives.

Background to these Comments

I have spent most of my over-40-year professional career devoted to sediment quality evaluation and contaminated sediment management. For 30 of these years I was a university professor at several major US universities, in which I had substantial research funding devoted to sediment quality evaluation, sediment quality criteria development and contaminated sediment management. I have published extensively on these issues. Copies of my recent papers and

reports are available from my website, www.gfredlee.com. Recent papers and reports include an update of the 1992 chapter in the Handbook of Dredging Engineering (Lee and Jones-Lee, 2000) (http://www.gfredlee.com/dredging.html).

Further, last fall I presented a paper entitled, "Appropriate Incorporation of Chemical Information in a Best Professional Judgment 'Triad' Weight of Evidence Evaluation of Sediment Quality" (Lee and Jones-Lee, 2002a), at the Fifth International Symposium on Sediment Quality Assessment (SQA5) held in Chicago, IL. A preprint of this paper is available from my website (http://www.gfredlee.com/BPJWOEpaper.pdf).

In addition, in December 2002 I completed a major report for the SWRCB and CVRWQCB on managing excessive bioaccumulation of organochlorine pesticides, PCBs and dioxins from contaminated sediments (Lee and Jones-Lee, 2002b) (http://www.gfredlee.com/OClTMDLRpt12-11-02.pdf). That report contained a discussion of why co-occurrence-based so-called "sediment quality guidelines" of the type that the SWRCB staff tried to develop in its original attempt are not technically valid and should not be used for any purpose, including screening of sediments. As discussed in my review of these issues, at the SQA5 conference, a number of invited keynote speakers all discussed why co-occurrence-based "sediment quality guidelines" are not a valid approach for evaluating and regulating contaminated sediments. A copy of a section of my SWRCB/CVRWQCB report is appended to these comments.

Specific Comments

Page 6, under 2.0 Program Approach, 2.1 Priorities and Additional Research, paragraph 2 states,

> *"These SQOs will not directly address the exposure of fish, wildlife, or humans to sediment contaminants. The protection of beneficial uses related to wildlife health and seafood consumption is extremely important, but the funds and time schedule for this project are not sufficient to complete this endeavor."*

This is a serious mistake on the part of those who developed this proposed plan. The food web uptake of contaminants from sediments that occurs to a sufficient extent to be a threat to human health is one of the – if not the – most important issues that should be addressed by sediment quality guidelines. While, as discussed in Lee and Jones-Lee (2002b), it is not possible to provide numeric chemical-specific concentrations in sediments that would prevent excessive bioaccumulation, it is possible, and it should be a principle component of this SQO development activity, to develop specific guidance on how the evaluation should be made to determine if potentially bioaccumulatable chemicals in sediments (such as the organochlorine pesticides, PCBs, dioxins) could bioaccumulate to excessive levels in edible organisms. These issues are discussed in detail in Lee and Jones-Lee (2002b).

As an example of work of this type, in cooperation with the DeltaKeeper, Dr. Scott Ogle and I conducted studies on city of Stockton Smith Canal sediments to determine whether they were likely the source of excessive bioaccumulation of PCBs in edible fish taken from Smith Canal. This 319(h) report (Lee, *et al*., 2002) was published as "Preliminary Assessment of the Bioaccumulation of PCBs and Organochlorine Pesticides in *Lumbriculus variegatus* from City of

Stockton Smith Canal Sediments, and Toxicity of City of Stockton Smith Canal Sediments to *Hyalella azteca*" (available upon request from gfredlee@aol.com).

On page 7, in section 2.2 Relationship to 1991 Workplan, item 1 indicates that the work on *"... human health risk assessment with follow-up assessment work"* will not be done. As discussed above, this is a serious error on the part of the State Water Resources Control Board, which must be changed if this SQO development process is going to address one of the most important issues to the people of California – i.e., excessive bioaccumulation of hazardous chemicals from waterbody sediments.

Page 7, item 2 states,

> *"...some elements previously included under this task in the 1991 Workplan such as compilation of sediment quality data, calculation of chemical effects ranges, and development of narrative SQOs are included as elements ..."*

It is very important that the State Water Resources Control Board not attempt to develop chemical effects ranges. This is a fundamentally flawed approach that cannot possibly succeed in developing meaningful Sediment Quality Objectives. As is well known by those who understand the elements of aquatic chemistry and sediment toxicity, chemical effects ranges can only meaningfully be developed based on an assessment of the chemical concentrations of the toxic-available forms of the constituents responsible for toxicity. It is not possible, as has been attempted in the past, to use total concentrations. If the SWRCB attempts to use total concentrations in this SQO development effort, this effort, like the previous one, will fail, and will waste large amounts of public funds in an ill-conceived SQO development activity.

Page 7, item 3 indicates that *"...AETs and other types of numerical guidelines will be conducted...."* This would be another serious mistake, because of the fact that AETs are based on total concentrations of constituents, and it has been known since the 1960s that the total concentration of a chemical constituent in sediments is not a reliable indicator of its potential impacts.

Page 7, item 5, Field validation of equilibrium partitioning, states, *"These studies are not included in the current workplan due to time and budget constraints."* That is not a proper reason for not including them. Those who are familiar with the literature on the US EPA's over-10-year effort to try to develop equilibrium-partitioning-based sediment quality guidelines, know that that approach eventually had to be abandoned because of the fact that the simplistic equilibrium partitioning approach is not a valid basis for developing Sediment Quality Objectives.

With respect to page 7, item 6, Spiked bioassays, I strongly concur that spiked bioassays are not a reliable approach and should not be included in the current Workplan.

Page 7, item 7 states,

> *"Recent data collected by Southern California Coastal Water Research Program (SCCWRP) suggest that these guidelines may have the predictive capacity to protect beneficial uses in California."*

Great caution should be exercised in proceeding along that approach. If it is based on total concentrations, then it should not be followed. If it is based on the toxic or bioavailable fraction, then possibly this approach might have some merit.

Page 8, item 8 states that the biomarker, etc., approach will not be followed. Biomarkers were never considered, by those who understand these issues, a reliable approach. All work on that effort in the previous SWRCB BPTCP effort was a waste of funds. Item 8 further states, *"The current workplan intends to develop or evaluate evaluation tools for the assessment of benthic community impacts ... and chronic sediment toxicity."* That is an appropriate issue for the Workplan to address, if it is done correctly.

Page 8, item 9 states, *"This element included activities to identify options for the prevention, minimization, and remediation of impaired sediments, such as source identification, loading estimates, control methods, and treatment approaches."* As discussed in my previous comments, the approach of trying to identify sources that the SWRCB staff proposed in the previous BPTCP effort was obviously technically invalid, and should not be included.

On page 8, an item 10 should be added to the list of objectives – namely, an assessment of the water quality impacts of contaminated sediments should be developed as part of this effort. As discussed in my comments on this issue, there are many naturally toxic sediments which have excellent fisheries in the waterbody overlying the sediments. Part of the effort of this Sediment Quality Objective development must be the appropriate use of the SQOs in the water pollution control program. Without this, simply developing numeric criteria or testing procedures, without the guidance on how they should be used, will be seriously deficient in meeting the needs for Sediment Quality Objectives.

Page 9 states, in 3.0 Scope of Work, 3.1 Program Guidance and Scientific Technical Review, that *"Annual public meetings and workshops will be held…."* It is important that the public be an integral part of this effort, and not just receive annual reports. This was one of the problems with the previous studies, in that the State Board staff was able to go for years without having to make reports. By that time, it was too late to correct the errors that were made by the State Board staff in developing the previous program.

Page 9, paragraph 2 states that, *"A Scientific Steering Committee (SSC) will be established to assist in the design of studies, data analysis and interpretation, …."* It is important that that Scientific Steering Committee not be selected to be a "rubber stamp" for the State Board staff efforts, as occurred previously. Individuals knowledgeable in the topic areas should be members of this Steering Committee.

Page 9, section 3.2 Sediment Quality Database Development, states in the first paragraph that, The data collected in previous studies *"...will be used to determine the relationships between contamination and biological effects ...."* The previously conducted studies, in many areas, were not adequately done to properly make this assessment. A prime example of this is the Upper Newport Bay studies, where only a few selected parameters were measured. Key parameters were not measured. As a result, the database that was generated is largely unusable to establish any relationship between degree of the contamination and effects. This same situation occurs in San Diego Bay and elsewhere. It is clear that a much more comprehensive, reliable approach needs to be conducted to establish the degree of contamination of the sediments and any potential relationship to adverse effects on aquatic life and excessive bioaccumulation.

Page 10, first paragraph, before I can comment on the adequacy of the existing database developed by the Los Angeles Contaminated Sediments Task Force, I will need to examine this database. Is it available online, and has it been discussed, in terms of its technical quality and appropriateness?

With respect to page 10, section 3.3 Benthic Community Assessment Index Development, at this location and elsewhere mention is made that, *"The emphasis of SQO development project is to develop objectives that will protect the most sensitive aquatic species...."* Care should be taken in focusing just on ultra-sensitive species. The proper approach to take to evaluate the significance of sediment toxicity is to test the sediments on a variety of sensitive species and then, through a best professional judgment weight of evidence approach, determine the water quality/beneficial use significance of the toxicity that is found. This is the approach that is discussed and advocated in the previously discussed paper (Lee and Jones-Lee, 2002a) that was presented at the SQA5 conference in Chicago last fall.

Page 11, section 3.4 Effects Assessment and Guideline Performance Analysis, states (in this section and elsewhere) that, *"Analyses of the statewide sediment quality database will be conducted to identify important aspects of the relationship between sediment contamination and effects in California."* As discussed above, the database that is needed to do this reliably does not exist. Because of the misdirection and mishandling of the previous studies, the database that should exist now was not developed.

Page 11, section 3.4.3 Assess Existing Sediment Quality Guidelines for Predicting Biological Impacts, should be deleted. The existing guidelines are obviously technically invalid. They have no predictive capability and should not be used for any purpose.

With respect to page 12, section 3.4.4 Evaluate Fish Bioaccumulation Models, it is clear that those who developed this are not familiar with the literature on this topic. There are no reliable models that can be used to predict bioaccumulation based on chemical concentrations in the sediments. This issue is discussed in detail in the Lee and Jones-Lee (2002b) report to the SWRCB/CVRWQCB.

Page 12, section 3.5.1 Develop Proposed Numeric SQOs, states, *"Numeric values representing chemical-specific threshold concentrations will be developed and evaluated."* This

approach is doomed to failure. This is an issue that has been addressed since the 1970s. Each time it has been tried, it has failed. The SWRCB should not waste any more time on this effort. Rather than trying to get chemical concentrations which predict impacts, they must work toward developing a regulatory approach based on chemical impacts – i.e., toxicity, bioaccumulation, etc. – which are related to toxic-available forms in the sediments.

The statement in this paragraph about using ERMs, AETs, etc., reflects a lack of understanding on the part of those who developed this statement, of the relationship between the chemistry of constituents in sediments and their impacts on water quality. This approach is a waste of time, and should not be used. These are not just my views. There are numerous people who understand these issues who strongly condemn any attempts to use chemical concentrations as a means of predicting chemical impacts.

With respect to page 13, section 3.5.3 Perform Bioaccumulation-based Objectives Case Study, the write-up in this section reflects a lack of understanding of the literature on the topic. There is no way to reliably relate chemical concentrations of constituents in sediments and bioaccumulation. Bioaccumulation must be assessed based on benthic organism uptake of the chemicals in sediments. As discussed by Lee and Jones-Lee (2002b), the US EPA (2000) has developed this approach, involving the development of a site-specific Biota-Sediment Accumulation Factor (BSAF), since the chemical concentration approach has been found to be unreliable.

Page 14, section 3.6.2 Applications and Enforcement, should be expanded to include an assessment of what it means to have "toxic sediments" to the beneficial uses of a waterbody. This is a key issue that must be addressed if this effort is to develop meaningful results.

Overall Assessment

Overall, the proposed Workplan is an improvement over previous workplans; however, it is still largely misdirected toward trying to develop chemical-concentration-based objectives. This approach is obviously flawed and should not be used. The effects-based approach should be used. It can provide reliable information, if properly implemented.

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Unreliability of Sediment Co-Occurrence-Based Approaches for Evaluating Aquatic Sediment Quality[1]

G. Fred Lee, PhD, PE, DEE and Anne Jones-Lee, PhD
G. Fred Lee & Associates
El Macero, CA
Ph 530 753-9630, Fx 530 753-9956, Em gfredlee@aol.com
www.gfredlee.com

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Beginning in the 1980s, several individuals ignored the well-established fact that the total concentration of a constituent in sediments is an unreliable predictor of aquatic life toxicity. The most notable of the inappropriate approaches that have been advocated for evaluating sediment quality is the co-occurrence-based approach first developed by Long and Morgan. Long and Morgan (1990) proposed co-occurrence-based sediment quality "guidelines" to predict the impact of sediment-associated chemicals on aquatic life living within or upon sediments. The co-occurrence-based approach as used by Long and Morgan and others such as MacDonald (1992) involves compiling sets of sediment data that contain some information on sediment biological characteristics, such as laboratory measured toxicity, or benthic organism assemblages (numbers and types of organisms) and the **total** concentration of potential pollutants. The potential pollutants are those that are typically considered in water quality assessments that have been found in some other non-sediment-related situations to be toxic to aquatic life. The literature reported concentrations are ranked according to increasing concentration. The sediment concentration which has a so-called "effect" is used to develop a co-occurrence between a sediment chemical concentration measured as a total concentration and a water quality "effect."

Lee and Jones-Lee (1996a,b, 2002a) have provided a detailed discussion of the lack of technical validity of the co-occurrence-based approach for evaluating sediment quality. As they point out, this approach has a number of inherent, invalid assumptions. First, the approach presumes that there is a causal relationship between the concentration of each contaminant considered in sediment and the water quality impact of that sediment. Second, it presumes that the "effect" reported for each sediment was caused independently by each of the measured chemical contaminants in that sediment. Third, it presumes that no other chemical or condition not included in the database has any influence on the manifestation of the "effect" that co-occurs with the particular chemical of focus; ignored are several sediment-associated contaminants and conditions that are well-recognized to cause aquatic life toxicity, including ammonia, hydrogen sulfide, and low dissolved oxygen. Fourth, it presumes that the assessments made of "effects" of the sediments relate in some meaningful way to adverse impacts on beneficial uses of the waterbody in which the sediments are located.

In regulatory applications, co-occurrence information has been used or proposed for use, albeit incorrectly, to establish various "effects threshold" values. That is, applying statistics to

[1] Excerpts from Lee and Jones-Lee (2002b)

the ranked listing of co-occurrence information of a given chemical, it was determined for that data set the concentration of the chemical that has a given probability of co-occurring with an impact, or the lowest concentration with which "no effect" co-occurred for that set of sediments. Examples of these approaches are the "Apparent Effects Threshold" (AET), and numeric values developed from Long and Morgan's (1990) data presentation in the form of ER-L and ER-M values, and "Probable Effects Levels" (PEL) values derived from MacDonald's (1992) co-occurrence compilations. If a sediment contains a chemical in concentrations above the AET, PEL, or similar value, the sediment is considered by some regulators or proposed regulations to be "polluted," and to require special consideration such as "remediation," alternate methods of dredged sediment disposal, or control of permitted discharges to the waterbody of a chemical that accumulates in the sediments.

As discussed by O'Connor (1999a,b, 2002), O'Connor and Paul (2000), O'Connor, *et al*. (1998), Engler (pers. comm.), Ditoro (2002), Chapman (2002), Burton (2002), Lee and Jones (1992), and Lee and Jones-Lee (1993; 1996a,b; 2000, 2002), the co-occurrence approach is not a technically valid approach for assessing the potential impacts of chemical constituents in sediments. It has been well-known for over 30 years that the total concentration of a chemical constituent in sediments is not a valid measure of the toxic/available forms of constituents that can impact aquatic life through toxicity or cause other impacts. Further, and most important, co-occurrence is not a valid basis for simple systems with a limited number of constituents for evaluating the cause of a measured impact. Co-occurrence is obviously not valid for relating the concentrations of sediment-associated potential pollutants to observed laboratory-measured toxicity or altered organism assemblages in which the chemical constituent of concern is measured. In normal situations, there is no valid cause-and-effect relationship between the total concentration of a chemical constituent in a sediment and its responsibility for some measured "impact."

As more and more data were accumulated that showed that the Long and Morgan and MacDonald guideline values were not reliable predictors of sediment toxicity and other impacts, Long and his associates tried to improve the reliability of the co-occurrence-based approach by using the normalized summed quotients for several chemical constituents to establish the value for comparison with the biological characteristic of the sediments determined by their co-occurrence evaluation. While not discussed by Long and Morgan and others who advocate this approach, the magnitude of the normalized summed value depends on the constituents included in the data review. While for highly degraded areas there is some claimed success for the expanded approach, the expanded co-occurrence approach is also not valid to relate the concentration of a single chemical constituent or a group of constituents' impacts on sediment and overlying water quality/beneficial uses.

Even though it is well-recognized that the Long and Morgan (and, subsequently, MacDonald) co-occurrence approaches are not valid tools to evaluate the potential significance of a chemical constituent in a sediment, there is continuing use of the co-occurrence-based guideline values as regulatory goals upon which control programs, such as TMDLs, are based. This arises from a lack of knowledge and understanding of sediment chemistry and toxicology/biology by those who are responsible and/or interested in sediment quality management.

Those who advocate use of co-occurrence-based sediment guidelines frequently claim that there are insufficient funds available to conduct the needed biological-effects-based evaluation of sediment chemistry and toxicology/biology to properly evaluate the water quality significance of a constituent in sediments. Since total chemical concentration data are frequently available for sediments, and since co-occurrence approaches superficially seem to provide a way to use these data in sediment quality evaluation, the co-occurrence-based approach receives use by regulatory agencies in order to provide some "information" on sediment quality without having to spend any significant amount of additional funds in sediment quality evaluation. There is also a strong desire by some to do something in addressing sediment quality even if there is an inadequate technical information base to enable a reliable sediment quality evaluation to be made. Such an evaluation would require detailed study of the sediments' aquatic chemistry/toxicology/biology.

One of the most significant recent inappropriate uses of co-occurrence-based approaches for regulating sediment quality has been proposed by the US EPA (2002c) Region 9. The Agency used the Buchman (1999) "NOAA Screening Quick Reference Tables (SQuiRTs)" to obtain TMDL targets for managing excessive bioaccumulation of organochlorine pesticides and PCBs in Upper Newport Bay, Orange County, CA, and its tributary San Diego Creek. The organochlorine chemicals of concern (for which there is excessive bioaccumulation in the Upper Newport Bay and its tributaries) are chlordane, dieldrin, DDT, PCBs and toxaphene. In discussing numeric targets for organochlorine TMDLs, the US EPA (2002c) states,

> *"As discussed in Section II, EPA evaluated the applicable water quality criteria and sediment and tissue screening levels to determine the appropriate numeric targets for these organochlorine TMDLs. We have prioritized sediment quality guidelines over tissue screening values and water column criteria. This decision is based on the following factors:*
>
> *1) these pollutants are directly associated with sediments (i.e., fine particulate matter);*
> *2) sediments are the transport mechanism for these organochlorine compounds from freshwaters to salt waters;*
> *3) limited water column data are available to adequately describe the past or current conditions; and*
> *4) attainment of the sediment targets will be protective of the water column criteria and tissue screening values."*

This approach and the reasoning in support of it are fundamentally flawed from several perspectives. First, the so-called "NOAA SQUIRT values" are co-occurrence-based values that evolved out of the Long and Morgan and MacDonald work. The biological effect used to establish these values did not consider bioaccumulation. Further, critical human health bioaccumulation concentrations in edible fish are frequently far below any concentration that is adverse to the host organism (fish). There is no relationship between the co-occurrence values of Long and Morgan and MacDonald and the potential for a chemical constituent in sediments to bioaccumulate to excessive levels in edible fish tissue.

With respect to the first and second justification listed above in support of this approach, the fact that a chemical tends to become associated with sediments is not justification for using co-occurrence to predict excessive bioaccumulation. As far as the validity of the third justification, those familiar with bioaccumulation situations know that measurement of constituents of concern in the water column is not a reliable approach for predicting the bioaccumulation of organochlorine pesticides, PCBs, dioxins, etc. With respect to the fourth justification in support of this technically invalid approach, because of its fundamental unreliability, it is inappropriate to say that it is either under- or over-protective.

There is no reliable way to relate sediment concentrations of organochlorine pesticides and PCBs to excessive bioaccumulation of these chemicals in edible fish tissue except through site-specific studies. This issue is discussed in a subsequent section. The US EPA Region 9 has made a serious error in using the Buchman SQUIRT co-occurrence-based values. This approach should be immediately abandoned in favor of fish tissue target values developed by the CA Office of Environmental Health Hazard Assessment. These values are appropriate TMDL goals for managing the excessive bioaccumulation of organochlorine pesticides and PCBs.

The approach that should be followed in evaluating the water quality/sediment quality significance of a chemical constituent in sediments was defined by the US EPA and the Corps of Engineers in the 1970s for regulating contaminated dredged sediments. As discussed above, the US EPA/US ACOE (1991, 1998) developed dredged sediment quality evaluation manuals which provide detailed guidance on determining whether the management of a contaminated dredged sediment in a particular manner will impact water quality of the receiving waters where the management/disposal of the dredged sediment takes place. These agencies used a biological-effects-based approach rather than a chemical-concentration-based approach – e.g., rather than measure copper in the sediments and then speculate about the copper toxicity and its sediment/water quality impacts, the US EPA/US ACOE approach measures toxicity and then uses Toxicity Investigation Evaluations (TIEs) to determine its cause.

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