San Francisco Bay Copper Water Quality Issues

G. Fred Lee
G. Fred Lee & Associates
27298 E. El Macero Dr.
El Macero, CA 95618
www.gfredlee.com

February 1, 1993

Pamela Lloyd, Chairperson
San Francisco Bay Regional Water Quality Control Board
2101 Webster Street, Suite 500
Oakland, CA 94612

Dear Chairperson Lloyd:

I am contacting you to provide comments on the San Francisco Bay Regional Water Quality Control Board staff's draft report entitled, "*Wasteload Allocation for Copper for San Francisco Bay.*"

First, I do want to commend the San Francisco Bay Regional Board and its staff for their forwarding efforts in the State in developing and planning for implementation of site-specific objectives for copper in San Francisco Bay. In our October 19 and 25, 1992 comments to the Board, we pointed out what we found to be technical deficiencies in the details of what was done in the development of that objective and in the number derived. However, we do recognize the substantial strides made by the Board and staff in the right direction of trying to develop and implement the objectives. We hope that the comments we provided will further the efforts of the Board and staff, and indeed the State, in the incorporation of sound technical information and evaluation of these issues.

In the spirit of trying to assist the Board and staff in its efforts with our technical expertise and experience in the area of impacts of chemical contaminants on water quality, that I submit these comments on the draft staff report on wasteload allocation for copper. As you will see, the comments address a range of topic areas, each directly pertinent to the issue of developing a mass emissions strategy and wasteload allocation for copper to San Francisco Bay. They are based on my more than 30 years of university research (amounting to millions of dollars) and practical and ongoing experience devoted to evaluating and developing management approaches for heavy metals and other contaminants in various types of aquatic systems.

Introduction

The proposed wasteload allocation is purported to have been designed to meet the recently adopted site-specific water quality objective for copper in San Francisco Bay of 4.9 μg/L. Meeting that objective, in turn, is supposed to protect the designated beneficial uses of San Francisco Bay without unnecessary expenditure for unjustified copper control. The proper

formulation of a wasteload allocation, therefore, should require the prior development of the following information:

- identification of a real water quality problem (impairment of a designated beneficial use) in San Francisco Bay caused by copper,
- development of an appropriate water quality objective to eliminate the designated-beneficial-use-impairment,
- understanding the role of copper sources to the Bay in contributing to those concentrations that caused the use-impairment,
- determination of the necessary reduction of loads from each source currently contributing to the exceedance that would result in achievement of the objective and thus the elimination of the beneficial-use-impairment.

However, a review of the draft staff report covering the development of the wasteload allocation for copper for San Francisco Bay shows that none of these key elements has been reliably developed. Dr. Jones-Lee's and my comments presented herein discuss key technical deficiencies in the approaches and recommendations in the staff report and discuss how the elements listed have not been reliably addressed. Some may question the appropriateness of our noting the deficiencies in accounting for those key elements in the draft staff report. However, it is clear that the reliability and cost-effectiveness of a wasteload allocation are only as good as the understanding of each of those elements. If those assessments are technically flawed, the wasteload allocation is itself technically flawed.

Some may also assert that it is inappropriate to discuss alternative bases for implementation of objectives, i.e., the application of the objectives to "dissolved" copper rather than to "total recoverable" copper. However, in light of the fact that there are proposals before the State Board at this time to adopt "dissolved" forms as the basis for application of heavy metal criteria and objectives, and that this is the approach being adopted with US EPA sanction in many other states, I believe that it is clearly appropriate and indeed important, to discuss the potential significance of such a change to the evaluation of a proposal for wasteload allocation for copper for San Francisco Bay.

In our previous comments to the Board (Lee, 1992a,b) we asked the Board and staff if a beneficial use impairment of San Francisco Bay had been caused by copper. The response was that while no problem had been identified, there could be a problem that has not yet been found. It was, and still is, our position that it is highly inappropriate to force the public and private interests to spend large amounts of money to reduce existing copper inputs to the Bay and its tributaries on the basis of the staff's notion that, despite extensive study that did not demonstrate a problem, there still might be some yet-undiscovered water quality problem in San Francisco Bay that might be caused by copper.

The fact that copper has not been found to cause a beneficial use-impairment problem in San Francisco Bay has significant implications for the steps being taken to develop and enforce mass emissions strategies and wasteload allocations for copper. Because no problem has been identified, the strategy and proposed wasteload allocation focus on achieving a numeric objective for copper, itself of unreliable technical foundation and the achievement of which cannot be shown to improve the beneficial uses of San Francisco Bay by correcting an existing problem.

Because of the far-reaching and potentially precedent-setting effects of the adoption of the proposed wasteload allocation, serious consideration must be given to the elements listed above and to the technical information we offer in these comments.

Overall Comments

Water Effects Ratios

The staff recognized that the application of the US EPA 2.9 µg/L copper criterion (and also the water quality objective) to San Francisco Bay waters was overly protective. It attempted to correct the problem by developing a site-specific copper objective based on a "water effects ratio" adjustment. That adjustment resulted in the formulation of the 4.9 µg/L site-specific objective for San Francisco Bay that will be in effect when it is adopted by the State Board. As discussed in our October 19 and 25, 1992 comments to the Regional Board, however, while the approach used for the development of the site-specific objective was in accord with the US EPA procedure recommended in the early 1980's, it is technically unreliable. This results from the assumptions implicit in the approach that the water quality impacts of all sources/forms of copper are the same - whether the copper is copper metal from brake shoes, particulate copper such as precipitates or sorbed species, copper-organic complex associated with soluble or particulate organics, or soluble aquo-species - and that independent of the form of copper added to the Bay, there would be essentially instantaneous equilibration that would result in the same forms of copper as those that would occur if reagent-grade copper sulfate had been added to the Bay. An understanding of elementary principles of aqueous environmental chemistry of copper shows the inappropriateness of those presumptions.

As discussed in our previous comments, the water effects ratio testing done is another example of application of worst-case assumptions and disregards the facts that different forms of copper added to Bay water will have different impacts and that many forms of copper in natural waters do not equilibrate to those forms predicted by thermodynamics even after extended periods of time. It is the lack of equilibration that causes the test conditions in the water effects ratio testing to grossly overestimate the toxicity of copper in the Bay to various forms of aquatic life.

Efficacy of Proposed Wasteload Allocation

On October 25, 1992 we submitted comments to the Board concerning statements made by Mr. Ritchie on October 21 in his announcement of the development of a mass emissions strategy for control of copper to San Francisco Bay directed at trying to achieve the 4.9 µg/L site-specific objective. As we discussed, the approach proposed, which is basically the same as that set forth in the January 8, 1993 draft staff report on wasteload allocation for copper for San Francisco Bay, will not cause the achievement of the 4.9 µg/L objective. Mr. Ritchie indicated, as does the January 8, 1993 draft staff report, that if the 4.9 µg/L objective is not achieved by the proposed load limitations, the loads will have to be reduced further. As discussed below, the January 8 draft staff report acknowledged that the staff had no model covering the relationship between copper added to the Bay and copper in the watercolumn in the Bay that leads to exceedance of the objective. As discussed in previous comments, however, a "model" is not needed to show

that, independent of the external loads of copper to the Bay (including the condition of "zero" load from all external sources), the 4.9 µg/L copper objective (applied to "total recoverable copper") cannot be achieved. This is because of periodic resuspension into the watercolumn of sediment-associated copper. Thus it is clear that the staff's proposed approach for achieving the site-specific objective is fundamentally flawed.

Since exceedances of the 4.9 µg/L objective will still occur with the proposed load-reduction approach (even with "zero" external load), and since no water quality problems have been found to be caused by exceedances of that objective even at the current loading levels, one must ask what purpose is served by the massive expenditures that will be required to accomplish the load reductions. Is it appropriate for the San Francisco Bay Regional Board to adopt approaches that set in motion the requirement for all contributors of copper to the Bay and its tributaries to achieve an arbitrarily developed load reduction that obviously will not result in achievement in the water quality objective?

US EPA Annapolis Workshop

Last week, I was an invited attendee at a US EPA workshop held in Annapolis, MD, devoted to review of the approaches being used by the US EPA in developing water quality criteria and, most importantly, in guiding their implementation into NPDES discharge limitations by the states. More than 50 professionals with recognized expertise in the area of concentrations of metals and impacts of those metals on water quality, participated in the workshop. It is unfortunate that members of the San Francisco Bay Regional Board staff, and for that matter members of the Board itself, were not present to hear the discussion at that workshop.

Copper was the contaminant most frequently discussed at the workshop. The situation in which numeric copper standards (objectives) are exceeded without concomitant water quality problems is not restricted to San Francisco Bay. As discussed in previous correspondence, this is occurring throughout the country. In fact, that situation was a primary impetus for the US EPA to conduct this workshop. It may be concluded from the workshop that no regulatory agency should force NPDES-permit-holders to reduce inputs of copper, or for that matter many other heavy metals, to a waterbody when the exceedances are determined based on analysis after strong acid digestion ("total recoverable metals").

Basis for Application of US EPA Water Quality Criteria

There was unanimous agreement among the participants at the US EPA workshop in Annapolis that total concentrations of heavy metals in water or sediment were not a valid basis for evaluating water quality impacts or regulating heavy metal discharges. Investigator after investigator presented results of recent studies that showed that the primary reason for the unreliability of "total" heavy metals is their association with particulates (suspended and deposited sediment) as well as with dissolved organics. The workshop culminated in a vote among the participants about the validity of continuing to use concentrations of total heavy metals ("total recoverable metals") as a basis for implementation of the US EPA water quality criteria for heavy metals. The result was a unanimous position that such an approach grossly

overestimates the impacts of heavy metals on water quality and would lead to massive waste of public and private funds for unjustified "control" of heavy metals in water and sediment. It was also recognized that dissolved metals should be the basis upon which water quality criteria should be implemented, and that with few exceptions that approach, itself, would be overly protective.

Several of the speakers at the US EPA workshop indicated that it has been their experience that "exceedances" of water quality standards for heavy metals based on "total recoverable" forms of metals largely, if not completely, disappear when the "dissolved" forms are used for implementation of the US EPA criteria into state standards. According to participants at the US EPA workshop, 16 states have already adopted heavy metal standards based on "dissolved" forms. This was done before the Annapolis workshop; the states' pollution control staffs and regulatory agencies had already concluded that total recoverable forms were not appropriate for use in regulating heavy metals in aquatic systems. There can be little doubt that as the information developed at the Annapolis workshop becomes widely known, additional states will establish water quality standards for heavy metals based on dissolved forms.

It was unbelievable that members of the San Francisco Bay Regional Board staff would testify at the State Water Resources Control Board workshop held on November 23, 1992 regarding revisions of the Inland Surface Waters and Enclosed Bays and Estuaries Plans and associated objectives that it opposed the adoption of dissolved forms as a basis for implementing water quality objectives. In taking that position, the staff is ignoring the basic principles of aquatic chemistry and aquatic toxicology that are well-established in the technical literature; in that respect the staff is out of tune with their colleagues in many other state regulatory agencies throughout the rest of the country, and with the technical community. If the San Francisco Bay Regional Board allows the staff's approach to prevail, it will unquestionably be leading to the waste of massive amounts of public and private funds controlling inputs of copper and other heavy metals to San Francisco Bay which, based on the best information available today, will result in no improvement in water quality in the Bay.

Analytical Chemistry Issues - Quality of Existing Database

Another very important conclusion of the Annapolis workshop was the realization that the majority of the heavy metal data that have been collected on ambient waters in the US, using US EPA-approved procedures and QA/QC approaches, is unreliable because of contamination of the samples that is not prevented by following the approved approaches. While teaching and conducting research at the University of Wisconsin in the 1960's, I supervised the work of several Masters and Ph.D. students in their theses and dissertations devoted to evaluating the aqueous environmental chemistry of several heavy metals, including copper, in relation to their impacts on water quality. We found then, as many others did at that time, that in order to reliably determine ambient heavy metal concentrations in natural waters great care had to be taken in sample collection, handling, and analysis to avoid contamination problems. It was also evident then that routine chemical analyses for heavy metals on ambient water as was being practiced then, and for that matter as is being practiced now, would not likely produce reliable results. The basic problem is that in order to do reliable heavy metal analyses on ambient waters,

it is necessary to use "clean" or in some cases "ultra-clean" techniques, which necessitate conditions beyond those specified by the US EPA-approved approaches. The contamination of concern results from the normal handling of glassware and sampling apparatus, and the use of reagents not subjected to proper purification, etc., conditions that are insufficiently prescribed by the US EPA procedures or are not being practiced in the public and private routine analytical laboratories.

While these deficiencies in the US EPA-approved procedures for analysis of heavy metals in ambient waters have been recognized by those professionals in the field who have analytical chemistry backgrounds and who have worked on trace metal analyses in ambient water systems, it was not until the Annapolis workshop that others began to appreciate the very serious problem that that situation has caused in the quality of the heavy metal data on the Nation's surface and groundwaters. The reason that the problem is now surfacing is that for the first time efforts are being made to control heavy metal concentrations in ambient waters to meet the very low concentrations reflected in the US EPA criteria and state standards. Decisions are being made that can result in expenditure of tens to hundreds of millions of dollars in point- and non-point-source treatment to try to achieve those standards.

It was also recognized at the Annapolis workshop that there is no reliable way to "correct" the unreliable data because the errors are not consistent but rather depend on details of how the samples were collected and handled in the laboratory. Years and years of ambient water heavy metal data are now being characterized as "junk" (by participants at the recent US EPA workshop) because of the blind reliance on "standardized," "approved" methods. This situation has been predicted for many years and is of tremendous significance to the credibility of the US EPA program for management of toxicity from heavy metals in ambient waters, and many state programs.

A number of participants at the US EPA Annapolis workshop indicated that many of the so-called "exceedances" of "total recoverable" standards for heavy metals in ambient waters disappeared also when appropriate "clean" analytical techniques were employed. At this time I do not know if this is a problem in the data for copper in San Francisco Bay. I would not be surprised to find that much of the data on copper in San Francisco Bay waters is unreliable, as are the data from other parts of the country, and that reported concentrations are much higher than those actually present in the Bay. The Board should instruct its staff to carefully investigate this situation, and to use "clean"/"ultra-clean" sampling and analytical techniques to evaluate the true concentrations of copper and other heavy metals in the Bay waters. Such an effort may show that many of the "exceedances" of the copper objective that have been reported are an artifact of failing to use reliable analytical procedures for measurement of copper and other heavy metals in Bay waters.

The staff may try to argue, in an attempt to salvage the data for heavy metals in San Francisco Bay waters, that it has used "standardized" procedures and quality assurance/quality control (QA/QC). However, it has been known for many years that the execution of "standardized analytical methods" is no guarantee of reliable analytical results. Quality assurance and quality control programs of the type routinely used today, such as the US EPA's standard procedures, had been followed in the development of what has now been found to be unreliable heavy metal

data produced in accord with US EPA-approved procedures. The QA/QC programs in effect today do not address the problems with sample collection, handling, and analysis that led to the problems with the heavy metal data reported at the US EPA Annapolis workshop. QA/QC information of the type being generated today is clearly not sufficient to establish the validity of the analytical measurements for heavy metals and many other parameters.

I published a paper on what I coined as the "standard methods syndrome" in a National Academy of Science publication in 1969 (Lee, 1969). That paper was based on my extensive analytical chemistry background as applied to natural water systems, and my work on "standard methods" committees for several professional organizations. In that paper I discussed the fallacy of the presumption that the use of a "standardized method" produces results that are necessarily reliable and necessarily comparable among sampling sites or dates. An example of the "standard methods syndrome" and the problems it can cause is the chaos with regard to the heavy metal data generated throughout the country using the US EPA-approved "standardized methods."

It is now clear that the "cook-book" standard methods approach being used today for water quality evaluation and management will be revised; it is hoped that this will result in a significant improvement in the reliability of future data generated. However, it will require that much greater attention be paid to the site-specific reliability of any given analytical method and that the elements of appropriate analytical and aquatic chemistry as they apply to the sampling and analysis for trace contaminants in ambient water systems be incorporated into the conduct of all analyses. It will also significantly increase the cost of chemical analyses on ambient waters. While the emphasis at the Annapolis workshop was on heavy metals, it is well-known that these analytical problems also occur for many other constituents for which control programs are now being developed triggered by "exceedances" of US EPA criteria-based standards. Owing to the uncertainty of the quality of the analytical data upon which exceedances of copper and other metal objectives in San Francisco Bay have been determined, the San Francisco Bay Regional Board should not adopt the staff's recommended wasteload allocation for copper and other heavy metals. The first thing that has to be done is to determine whether the "exceedances" that appear in the database are real or an artifact of improper analytical procedures.

Questions of Reliability of the Copper Criterion Value

Another factor that was brought out at the Annapolis workshop, which is very important with regard to use of "exceedances" of US EPA criteria for heavy metals as a basis for regulating heavy metal discharges, is that there are now serious questions about the reliability of the US EPA criteria values, themselves, because of the way they were developed in the laboratory compared with conditions that exist in the field. There was agreement among many of the participants, including those involved in the development of the currently used criteria, that owing to uncertainties or ill-defined conditions that existed in the laboratories, the US EPA needs to re-do the laboratory work for the development of the heavy metal criteria to determine the proper criteria values and most importantly how they should be implemented. Those responsible for administration of the US EPA program for control of toxics voiced concern about having to re-do the criteria development work because it would take three to five years of effort. Starting such a program would undermine the US EPA's current efforts to implement the

National Toxics Rule. There is no question that that work should be done and that the National Toxics Rule should not be implemented until it is done. It is inappropriate to force the people of the country to spend large amounts of money in implementation of the National Toxics Rule when the foundation of the Rule, the criteria, are known to be of questionable reliability. There were many professionals across the country, including Dr. Jones-Lee and me, who commented on the inappropriateness of the US EPA's National Toxics Rule when it was proposed in November 1991 (Lee and Jones, 1991) because of the questionable reliability of the criteria and the inappropriateness of their being mechanically applied to establish discharge limitations for regulation of NPDES discharges if those discharges are to be regulated in a technically valid, cost-effective manner to address real water quality problems without significant unnecessary expenditures for unjustified contaminant control.

Water Effects Ratios

A major section of the Annapolis workshop was devoted to a discussion of the need for revisions of the procedures used to determine the "water effects ratio" for site-specific water quality criteria/standards development. The US EPA is developing a new "cook-book" for water effects ratio determination that should be out for public review within a year. From the discussions at the Annapolis workshop, there is little doubt that the guidance provided in the new "cook-book" will be revised from that provided in the water quality handbook released by the US EPA in 1983. It was the 1983 guidance that the San Francisco Bay Regional Board staff followed, to some extent, in its development of the 4.9 µg/L water quality objective for copper. It was recognized at the Annapolis workshop that following the 1983 guidance can readily lead to an inappropriate estimate of the toxicity of a contaminant in ambient waters, as it did in San Francisco Bay.

One of the areas of particular concern that was recognized by the workshop participants to be a major problem area with the water effects ratio determination is that the equilibration of forms of contaminants in sources of contaminants to a waterbody can be very slow, especially for particulate forms of contaminants; some forms will never equilibrate to thermodynamically predicted species, yet these forms would be measured in analytical procedures for total recoverable forms. This applies also to some of the dissolved forms of contaminants. While many of these problems in water effects ratio determinations will disappear when dissolved forms of metals are used as a basis for regulation, there will still be some equilibration problems that will cause even dissolved forms to not mimic the copper sulfate used as a source of copper in water effects ratio testing such as that which was done by the Regional Board staff and its contractors.

Ambient Water Toxicity Testing vs. Chemical Concentration Criteria

Several individuals at the Annapolis workshop stressed the importance of using ambient water toxicity measurements with highly sensitive organisms as the ultimate determiner of whether there is a real problem caused by heavy metal discharges, sufficient to justify alteration of NPDES discharge limitations. You may recall that this is the approach that Dr. Jones-Lee and I have advocated for a number of years (Lee and Jones, 1987). The first step in any program of this type is to find out if there is a real water quality problem in the waters receiving the

discharge. Ambient water toxicity testing has been sufficiently well-developed today to enable its use as a reliable tool for this purpose in most situations. If toxicity is found, efforts can then be made to identify and control the source of the toxicity; this is a much more technically valid, cost-effective approach for evaluation and management of contaminants that can adversely affect beneficial uses of the State's waters, including San Francisco Bay.

The use of appropriate toxicity tests as a method for regulating contaminants is not new. In their Blue Book of water quality criteria (NAS/NAE, 1973) the National Academies of Science and Engineering committees recommended that toxicity tests be used as the basis to establish limitations on heavy metal discharges because there were no reliable chemical analytical methods to assess the toxic forms of heavy metals. As evidenced by the discussions at the US EPA Annapolis workshop, there are still no reliable chemical analytical methods to definitively assess toxic forms of heavy metals in effluents or ambient waters. "Dissolved" forms are closer to the "toxic" forms of heavy metals than "total recoverable" forms of metals, but even some of the dissolved forms are not toxic. The use of toxicity tests to regulate heavy metal discharges was adopted by the US EPA in 1976 in its "Red Book" of water quality criteria (US EPA, 1976).

Unfortunately, in the 1980's the Agency abandoned the toxicity-based approach in favor of worst-case or near-worst-case numeric chemical concentration criteria for heavy metals. However, it has not been until the 1990's that efforts have been made to apply that approach for the regulation of discharges. What is being found is that what appeared superficially to be a bureaucratically more simple approach to administer, is causing chaos in the evaluation and regulation of discharges; it was not and is not a technically valid approach. As discussed by Lee and Jones-Lee (1992a) concentration-based criteria have utility to trigger concern about potential water quality problems in ambient waters that may be caused by those contaminants for which chemical concentration-based criteria have been developed. When those triggers are exceeded, assessments of ambient water toxicity should be used to better define whether there is in fact a real water quality problem, and as a basis for determining the degree of contaminant control necessary to protect designated beneficial uses of the Nation's waters. However, there is a myriad chemicals that could cause toxicity for which there are no numeric criteria. Ambient water toxicity testing assesses toxicity independent of the cause. Appropriate ambient water toxicity testing is a technically valid approach for evaluating and managing contaminant inputs from point-sources and non-point sources that could cause toxicity in the Nation's surface waters.

There are some in the US EPA who assert that the Agency has adopted a policy by which chemical concentration criteria and ambient water toxicity-based criteria are independently applicable. However, the reporting of that situation is not consistent among members of the Agency; the rule-making that is alleged to have established that policy was, as discussed by Lee and Jones-Lee (1992a), not subject to public review.

If the application/use of chemical concentration criteria is not appropriately adjusted, it will lead to massive waste of public and private funds for the development and implementation of control programs for heavy metals that are not causing real water quality problems in the waters receiving the discharges. Those in the US EPA who were responsible for making the decision to abandon the use of toxicity tests as the basis for regulating heavy metal discharges in favor of a chemical concentration approach are responsible for the chaos that exists today in the

inappropriate regulation of heavy metals in San Francisco Bay, and across the country. The Annapolis workshop discussions provide impetus for the Agency to correct those errors and get the country back on track toward developing technically valid, cost-effective evaluation and management approaches for toxic chemicals in the Nation's waters. Based on my 30 years of experience in the field, I am confident that the error made by the US EPA in the 1980's in shifting from toxicity-based control programs to chemical concentration-based programs will ultimately be corrected. Time should be allowed for federal and State agencies to straighten-out the science so that funds spent for copper control address real water quality problems.

Accounting for the Unknown

One of the participants at the Annapolis workshop repeatedly tried to convince the other participants that it is inappropriate to modify the US EPA criteria to account for site-specific conditions. It was that participant's position that adjusting the US EPA criteria values applied to "total recoverable" forms of heavy metals to more properly reflect the aquatic chemistry of the contaminants in the water of concern, could result in adverse impacts to some forms of aquatic organisms in the waterbody. That argument, you may recall, was also advanced in connection with the discussion of the appropriateness of using the 4.9 µg/L site-specific objective developed for copper in San Francisco Bay. It was asserted in connection with that argument that certain types of organisms are no longer present in some parts of San Francisco Bay and that that could be due to copper. As discussed in our previous comments, the Regional Board staff correctly criticized that argument noting that it presumed that all changes in the numbers and types of organisms in the Bay were due to that one chemical, and noted that there was no evidence that that situation was anything other than simply a "co-occurrence." As the Board is well-aware, there have been highly significant changes in numbers and types of organisms in the Bay that have had nothing to do with chemical inputs to the Bay. Dr. Jones-Lee and I have recently discussed the fallacy of the use of "co-occurrence" as a basis for identifying and ranking toxic hot spots in the State (Lee and Jones-Lee, 1993a,b).

At the Annapolis workshop members of the US EPA staff who had helped develop the approach for development of water quality criteria pointed out that the approach developed was subjected to peer and public review prior to adoption as National policy. I served as a member of the peer-review panel for the development of the criteria development approach. I am therefore highly familiar with the strengths and weaknesses of that approach. While anyone can claim that there might be some organism that might not be protected by the criteria, the likelihood of that situation's occurring and its being of significance to the beneficial uses of the waterbody is very small. As was pointed out by the US EPA staff at the Annapolis workshop, that argument should certainly not be used to prevent the adjustment of the US EPA criteria to site-specific conditions. It is highly unlikely that the US EPA criterion for copper of 2.9 µg/L would be protective of that yet-unidentified organism while the 4.9 µg/L site-specific objective (or even ambient concentrations) would not be. The US EPA staff also pointed out that if the yet-unidentified critical organism would not be protected by the US EPA criterion, a criterion development approach would have to be established and conducted to develop a suitable database and then a criterion for it; a criterion for an organism left unprotected by the current US EPA criterion cannot be developed from some arbitrary modification of the existing criterion. As discussed elsewhere in these comments, it is certainly not in the best of the people of the State to prevent

the use of the best technical information available today to formulate copper control strategies for San Francisco Bay based on the position, not substantiated with reliable technical support, that there might be some organism that might not be protected if a criterion other that the US EPA criterion (objective) were applied.

In Dr. Jones-Lee's and my previous comments to the San Francisco Bay Regional Board, we recommended that since a real water quality problem has not been found to be caused by the current loads of copper to San Francisco Bay, no further reductions in the existing loads should be implemented at this time. We support, however, allocation of funds to look for yet-unidentified problems. The funding for such an evaluation could be derived from the dischargers. If real beneficial use problems are identified that require the development of a new water quality criterion, the US EPA should become involved to review the applicability of the current criteria development approach and to develop a new approach if necessary, and a new criterion.

Algal Toxicity Tests

Another topic that was discussed at the Annapolis workshop that is of importance to the San Francisco Bay Regional Board in reviewing the appropriateness of the staff's approaches for determining potential impacts and regulating copper discharges to the Bay and its tributaries, is the use of algae as a test organisms. It was pointed out at the workshop by those responsible for developing the US EPA water quality criteria that there are significant problems with trying to use what they called "micro-algae" such as diatoms, etc. for this purpose. As we have discussed in a number of publication based on our many years of experience in working on factors influencing algal growth and on the control of nuisance algae (see Lee and Jones, 1991), the test conditions used to evaluate toxicity to algae are significantly different from those which exist in natural waters. The culturing conditions associated with testing of those organisms typically incorporate growth medium and concentrations of organisms that can drastically impact the results of the tests compared with what would occur under ambient water conditions. It is for those reasons that it is impossible to reliably interpret the results of algal toxicity tests in terms of potential impacts on beneficial uses of a waterbody. It is also for those reasons that the water effects ratio testing procedures did not specify algae as a suitable organism.

Implications of Workshop Discussions

The problems discussed at the Annapolis workshop are not newly "discovered." Many were described in publications at least as early as 1973:
Lee, G. F., "Chemical Aspects of Bioassay Techniques for Establishing Water Quality Criteria," Water Research 7:1525-1546 (1973). (invited review paper)

They have also been periodically re-examined and discussed as new information has become available, for example in:
Lee, G. F., Jones, R. A., "Interpretation of Chemical Water Quality Data," IN: Aquatic Toxicology, STP 667, ASTM, Philadelphia, pp.302-321 (1979). (invited review paper)

Lee, G. F., Jones, R. A., and Newbry, B. W., "Water Quality Standards and Water Quality," Journ. Water Pollution Control Federation 54:1131-1138 (1982).

Lee, G. F., and Jones, R. A., "Translation of Laboratory Results to Field Conditions: The Role of Aquatic Chemistry in Assessing Toxicity," IN: Aquatic Toxicology and Hazard Assessment: 6th Symposium, STP 802, ASTM, Philadelphia, pp. 328-349 (1984). (invited review paper)

A number of the individuals at the Annapolis workshop, including me, concluded that the toxics evaluation and management programs for ambient waters of the US EPA and many of the states are "in shambles." There are appropriate questions that must be addressed about whether a discharger should be required to undertake load reductions on the basis of the exceedance of a heavy metal standard applied to "total recoverable forms" in a waterbody listed as "water quality limited" owing to that exceedance.

The results of the Annapolis workshop provide strong support for many of those who testified previously on the inappropriateness of the approaches being followed by the Regional Board staff in addressing the exceedances of the water quality objectives for copper and other heavy metals. The realization that total recoverable metals are not a reliable basis for regulating heavy metals, the questions about the reliability of the US EPA water quality criteria that serve as the basic framework for regulation, the questions about the reliability of the ambient water copper data that have been use to identify so-called exceedances of objectives, and the problems with the use of water effects ratios to develop technically valid, protective but not unnecessarily overly protective water quality objectives, all point to the need for the Board to establish a moratorium on further work by the staff in developing wasteload allocations for copper and other heavy metals in San Francisco Bay.

The discussions at the US EPA workshop are extremely important in the Board's determination of whether it should proceed to implement the staff's recommended wasteload allocation for copper. Since there is no doubt that the US EPA will continue, as it has been for a number of years, to allow states to implement the US EPA water quality criteria based on dissolved forms of heavy metals, and since exceedances of the copper objective in San Francisco Bay apparently disappear if the criteria are implemented based on dissolved forms, there is no justification to cause any discharger of copper to the Bay to alter its current loads. There is obviously no need, and no justification, for developing a mass emissions strategy (wasteload allocation) for copper discharges to the Bay and its tributaries. Any discharger whose discharge limits to the Bay are reduced by the implementation of such a wasteload allocation would, in my opinion, be justified in challenging the additional restriction. My position has been strengthened by the information I heard presented and discussed at the Annapolis workshop.

While it might be asserted that the US EPA Region IX might try to force the Regional Board to proceed with its wasteload allocation for copper, I believe that this would not be likely in light of the Annapolis workshop. Such a step would clearly be inconsistent with what is being done in the rest of the country.

I believe that the results of the Annapolis workshop will provide significant impetus for the State Board to proceed with quickly adopting dissolved metals as the basis for implementing the April

1991 objectives. If the State does not do this, I believe that there will be massive litigation against the Board for continuing to impose what are well-recognized to be grossly overly protective objectives for heavy metals based on the use of total recoverable metals for implementation of the objectives. This situation alone should cause the Regional Board to tell its staff to stop all further work on wasteload allocations until such time as the State Board has resolved the issues of whether dissolved or total recoverable metals will be used to implement the water quality objectives.

If after what I feel will be the inevitable change to the implementation of objectives based on dissolved metals, there are real water quality problems found to be caused by copper or for that matter other heavy metals in San Francisco Bay, the Regional Board should instruct its staff to determine appropriate, site-specific objectives that reliably consider the aqueous environmental chemistry of the metal from the dominant sources to and within the Bay waters. If at that point there are exceedances of the objectives that reflect a real impairment of designated beneficial uses of Bay waters, the Regional Board should instruct the staff to develop a mass emissions strategy and wasteload allocation for the metal of concern. In my opinion, the earliest that situation could develop would be 3 to 5 years from now. It is very important to point out that delaying action on the development of a wasteload allocation for copper (should one prove appropriate for solving a real water quality problem in the Bay) for five years or so will not result in significant discernible impact on Bay water quality since no water quality problems have been found to be due to the current discharges of copper. However, it is also my recommendation that no significant new discharges of copper or other heavy metals to the Bay be allowed during this moratorium, in order to maintain the status quo. Further, if any discharge is found to be causing significant localized impacts near the point of discharge, that discharger should curtail the discharge of those contaminants causing the localized impacts. In addition, as discussed above, studies determined necessary to identify yet-unidentified beneficial use impairment should be undertaken to prepare for future triennial reviews.

A Board decision to not implement copper controls beyond those which currently exist does not imply that no additional controls can be required by the Board in the future should new evidence support such an action. In fact, by law, the Basin Plans must be reviewed every three years. Therefore, it will be necessary for the Board to revisit these issues periodically and make necessary adjustments in them to provide for protection of designated beneficial uses of the Bay based on the information available at that time. Conversely, if the Board supports the staff recommendation for a wasteload allocation for copper, it will set in motion massive litigation against the Board, and review of the appropriateness of the decision by the State Board. Further, because of the long lead-time needed to implement copper control of the type proposed by the staff, all sources of copper to the Bay and its tributaries will soon have to start spending public and private funds to develop control programs. At some time in the not-too-distant future, the amount of money committed by municipalities and others to copper control will be substantial and to some extent not recoverable. It is good common sense in the wise use of public and private funds to not implement the staff's recommended wasteload allocation for copper.

Other Issues

Consideration of Sediment Quality

One of the reasons advanced last fall by opponents of the staff's proposal to adopt the site-specific copper objective that raised the objective from 2.9 µg/L to 4.9 µg/L, was the claim that the higher copper levels could lead to increased contamination of sediment, which could be adverse to aquatic life. As discussed in our correspondence to the Regional Board, I have had more than 30 years' experience on issues of the interactions between sediment-associated contaminants and water quality, and have published extensively on the topic. In January 1992 we developed a comprehensive review of sediment quality issues as related to water quality (Lee and Jones, 1992b) which was provided to the Executive Officers of all of the Regional Boards. In that review we discussed that there is a wide variety of chemical (including biochemical) reactions that take place in sediments that detoxify many potentially toxic chemicals, including copper. We also pointed out that numerous other investigators have also found that there is no general relationship between the concentrations of contaminants in sediment and their impact on sediment-associated organisms or organisms in the overlying waters. This finding is fully expected based on the aqueous environmental chemistry of sediment-associated contaminants. Therefore, the basic premise of the claim that raising the 2.9 µg/L objective to 4.9 µg/L would increase the concentration of toxic forms of copper in sediment over that which would exist if the objective were left at 2.9 µg/L, is technically flawed. The issue is not whether the concentration of total copper in a sediment increases, but rather whether the concentration of toxic/available forms of copper in the sediment increase. A review of the aqueous environmental chemistry of copper shows that in the San Francisco Bay setting there is little likelihood that the current discharges of copper to the Bay increase the amount of available/toxic forms of copper in the sediments.

There are some who oppose the application of the copper objective (and thus the mass emissions strategy/wasteload allocation) to dissolved forms instead of "total recoverable" forms based on their conjecture that particulate components of the "total recoverable" forms can become associated with the sediment where those forms could dissolve-become available. The primary reason that the potential toxicity of copper, and many other heavy metals, to aquatic life in the watercolumn cannot be reliably assessed by the concentrations of "total recoverable" forms is that that measurement includes forms of copper associated with particulates. It is well-known that particulate forms of copper, as well as of many other heavy metals, are not available/toxic to organisms in the watercolumn. While there some who claim that there may be some organisms that are sensitive to particulate forms of copper, many years of work have not identified such sensitivities that would cause the water quality criteria values to be controlled by those types of organisms. A review of the aqueous environmental chemistry of copper shows that because of the dominant reactions that govern the availability/toxicity of copper in natural water systems, particulate forms of copper in the watercolumn that become part of the sediments would not likely become available in the sediment to be toxic to benthic or epibenthic organisms in or associated with the sediment, or to watercolumn organisms. In fact, there is a wide variety of reactions that convert dissolved forms of copper that are in the water overlying sediments to unavailable/non-toxic forms and bring them to the sediment. Therefore the argument advanced by some who oppose changing the basis of application of criteria and objectives from total recoverable forms to ambient water dissolved forms (that the particulate forms could become dissolved and create toxicity in the watercolumn or sediment) is strongly contrary to what is

well-known about the aqueous environmental chemistry of copper in water and sediment systems.

Assertions have been made at least with regard to other locations, that if the concentration of dissolved copper in the interstitial water exceeds the water quality criterion value of 2.9 µg/L, it will be detrimental to organisms living in the sediment and/or the overlying waters. There are several technical flaws in that argument. First, it is well-known that it is very difficult to reliably measure dissolved copper in interstitial waters. It is very difficult to collect a sample of interstitial water that retains the integrity of the interstitial water in the bedded sediment. Further, the measurement techniques used typically overestimate the concentrations of dissolved copper because they do not separate all of the particulate copper from the dissolved fraction. It is also becoming recognized that a number of heavy metals, including copper, form colloid-sized "particles" that are measured as "dissolved" because of the inadequacies of standard separation techniques, yet are not in true solution. Those colloidal forms certainly have different toxicological properties (likely lower toxicity) than copper in true solution. Second, even with proper measurement of dissolved copper in interstitial water, it is highly inappropriate to assert that the US EPA water quality criterion has any applicability to assessing the significance of dissolved copper in interstitial water. For one reason, the interstitial waters of sediment typically have a much higher content of organic matter that would tend to form soluble complexes with copper that would result in detoxification of the "dissolved" copper.

Another argument advanced in opposition to raising the water quality objective for copper in San Francisco Bay from 2.9 µg/L to 4.9 µg/L was that benthic organisms such as clams, which are filter feeders, could accumulate sufficient copper within them to adversely affect them. I have done considerable research over the years on the relationships between the concentrations of chemicals in water and sediment and their impacts on clams. It is well-known that adult clams and other bivalve molluscs are remarkably insensitive to potentially toxic chemicals. The sensitive forms of those organisms are the free-swimming larval forms. At one time a considerable amount of the testing of the potential toxicity of sediment-associated chemicals was done with adult clams. Such testing is now recognized to be inappropriate because of the lack of sensitivity of those adult organisms to many contaminants. Instead, the testing has shifted to larval forms of those organisms. In fact, the water quality criterion for copper in marine waters (2.9 µg/L) was developed based on the sensitivity to copper of the larval form of a mussel, Mytilus edulis. From the vast literature available today, it is clear that there is little likelihood that adult bivalve molluscs, or for that matter other benthic organisms, would be adversely affected by raising the water quality objective from 2.9 µg/L to 4.9 µg/L, or for that matter, to the current ambient concentrations of copper in San Francisco Bay. The same applies to changing the basis for implementing the copper objective from total recoverable forms to dissolved forms.

At the US EPA workshop at Annapolis, the issue of the relationship between water quality criteria and sediment quality was discussed; participants noted that it is highly inappropriate to use water quality criteria and standards to try to assess and regulate sediment character and "quality." There seemed to be general agreement that sediment quality issues should be addressed by specific assessment of toxic forms in sediment rather than from presuming inferences from the water quality criteria. Further, in his presentation at the workshop, G. Ankley of the US EPA indicated that his research showed that the detoxification of heavy metals

in sediment involves more than just reactions with acid volatile sulfides (AVS). He specifically mentioned the need to consider organics in sediment and hydrous metal oxides as important mechanisms for detoxification of copper and many other heavy metals. Ankley's recent statement on this matter is in accord with Dr. Jones-Lee's and my experience over the years on this topic; we discussed this issue in our sediment quality review last year (Lee and Jones, 1992b).

In summary therefore, there is no justification for the continued use of "total recoverable" forms of copper in San Francisco Bay waters as a basis for implementation of the copper objective. Further, there are no legitimate sediment "quality" issues that would provide justification for the staff's proposed wasteload allocation to reduce the copper loads in an attempt to achieve the 4.9 µg/L objective.

Applicability of Comments to Other Chemicals

While these comments are directed toward copper, they also have direct applicability to the concerns of the Board for nickel, and considerable applicability to the concerns for selenium and mercury. The aqueous environmental chemistry and toxicological properties of nickel are sufficiently similar to those of copper that with few exceptions, these comments are directly applicable to nickel. In the case of selenium, there is an apparently important food-web uptake mechanism. This additional mechanism causes the need to consider additional aspects or components of aqueous environmental chemistry in the formulation of a site-specific water quality objective and appropriate mass emissions strategy and wasteload allocation for selenium. In the 1960's, with a post-doctoral fellow, I did some of the early work on the chemistry of selenium in natural waters (Wiersma and Lee, 1971). I have conducted a review of the San Francisco Bay Regional Board's staff's draft staff report, "Mass Emissions Reduction Strategy for Selenium," dated October 12, 1992. I found its consideration of the chemistry of selenium to be in considerable error in ways that will cause significant technical errors to be made in the judgement of the significance of the concentrations of selenium in the water and sediment of San Francisco Bay and estuary.

For example, in establishing the watercolumn limit for selenium that serves as a basis for the mass emissions strategy and wasteload allocation, inappropriate assumptions were made about the interaction between selenium and particulate matter in the watercolumn. The staff's approach for estimating selenium uptake on particulate matter was apparently based on bioconcentration factors for selenium uptake by algae, apparently assuming that all uptake of selenium on particulate matter is represented by selenium uptake by algae. To the contrary, the extent of uptake of selenium on various types of suspended particulates can be substantially different from that of algae. Furthermore, in 1967 a colleague and I published an invited review paper entitled, "Biological Activity in Relation to the Chemical Equilibrium Composition of Natural Water" in which we discussed what was known about the relative abundance of various types of particulates that can serve as sites of sorption for contaminants in natural waters. We found that non-living organic particulates (detritus) are at least an order of magnitude more prevalent in water as living particles (algae and bacteria) and that bacteria are at least 10-times more prevalent than algae. Further, algal chlorophyll concentrations (and hence concentrations of algae) vary independent of concentrations of total particulate matter in a water. The staff report

provided an unreliable representation of the behavior of selenium in the waters of concern that will distort the conclusions drawn from, and actions taken based on, the assessment. The mass emissions strategy for selenium being proposed by the staff should not be adopted by the Board because of the technical deficiencies in the formulation of the coupling between the watercolumn limit and the no observed adverse effect level.

Specific Comments on Draft Staff Report
Wasteload Allocation for Copper for San Francisco Bay - Parts 1 and 2

Page 1, paragraph 2 of Part 1 of the draft staff report indicates the staff's position that Part 1 of the draft staff report meets the requirements for exemption of the proposed wasteload allocation for copper for San Francisco Bay from CEQA review. While the Secretary of the Resources Agency has reportedly, in the past, declared that statements such as the draft staff report are considered equivalent to CEQA review, I believe that this draft report should not be considered equivalent. The draft staff report did not properly consider the economic consequences of the proposed actions. It also did not consider the impact on environmental quality of the appropriation of funds that could have been used to address real environmental quality problems, for expenditure on the proposed activity (addressing administrative exceedances of an objective in San Francisco Bay). Any proposed program that sets in motion the expenditure of hundreds of millions of dollars in a control effort, should be evaluated for its economic impact in light of the benefits to be accrued from it.

On page 17 of Part 1, the staff quoted the following part of Section 13263 of the Porter-Cologne Act.
"The requirements shall implement relevant water quality control plans, if any have been adopted, and shall take into consideration the beneficial uses to be protected, the water quality objectives reasonably required for that purpose, other waste discharges, the need to prevent nuisance, and the provisions of Section 13241."

While the staff did not quote Section 13241 specifically mentioned in that passage, that section of the Porter-Cologne Act stated,
"Factors to be considered by a regional board in establishing water quality objectives shall include, but not necessarily be limited to, all of the following: ... (d) Economic considerations."

It is clear that by not providing a proper review and consideration of the economic issues associated with the water quality objective for copper and the proposed wasteload allocation developed in an attempt to achieve that objective, the staff has not meet the requirements of the Porter-Cologne Act.

Page 1, paragraph 5 (Part 1) indicates that in 1990 the State Water Resources Control Board adopted the Pollutant Policy Document that *"called for establishment of Mass Emissions Strategy (MES) for pollutants in the Bay and Delta."* It is very important to note, as I discussed in comments to the State Board (Lee, 1990), that that Pollutant Policy Document contained a fundamental flaw in that it is based on concentrations of total forms of contaminants rather than on those forms that are available or toxic in the Bay and Delta system. The technical issues of

the importance of focusing on available forms of chemicals were discussed in the general comments above.

In comments submitted to the State Board at the time that the State Board staff formulated the Pollutant Policy Document approach, we pointed out that it was well-known that limiting total concentrations of contaminants such as copper is inappropriate for regulating their potential impacts on water quality, if there is an interest in developing regulations that will protect designated beneficial uses of the waterbody such as the Bay and Delta without significant unnecessary expenditures for contaminant control (Lee, 1990; Lee and Jones, 1990a,b). The State Board's adoption of the technically inappropriate mass emissions strategy based on total contaminants commits the people of California to massive waste of public and private funds in the name of pollution control without a concomitant improvement in beneficial uses of the State's waters. The State Board should amend its Pollutant Policy Document and the associated mass emissions strategy requirements so that they more properly reflect the potential water quality significance of contaminants such as heavy metals in the Bay and Delta system.

Page 1 of Part 1 of the draft report gives the impression that the Regional Board has to follow the proposed approach because of US EPA regulations. That is not true. The federal regulations allow for the focus of contaminant control funds on real problems.

As discussed in previous statements submitted to the San Francisco Bay Regional Board (Lee, 1992a,b) the first step that should be done in any wasteload allocation process is to find out if there is a real water quality problem in the waterbody. The Regional Board staff has yet to find a real problem caused by copper. While it can conjure problems in an attempt to try to defend its current actions, after extensive study a problem still has not been found. As I discussed in previous comments to the Regional Board (Lee, 1992a,b), since the issues are reviewed every three years, the focus now should be not on adopting a mass emissions strategy for copper, but on developing appropriate water quality objectives that properly reflect the behavior of copper added to and within the San Francisco Bay.

The first paragraph on page 2 (Part 1) states,
"The purpose of this project is to establish an implementation program for meeting the site specific water quality objective for copper of 4.9 µg/L based on the reduction of mass loading of copper to San Francisco Bay and estuary."

As discussed above and in previous comments (Lee, 1992a,b), the 4.9 µg/L water quality objective for copper that has recently been adopted by the San Francisco Bay Regional Water Quality Control Board was not reliably developed to protect designated beneficial uses of San Francisco Bay without unnecessary expenditure for contaminant control. That value is grossly overly protective. If the Regional Board staff cannot find a real water quality problem in San Francisco Bay due to ambient water copper (which is at times a factor of 10 or more above the water quality objective adopted by the Regional Board), there can be no justification to adopt a water quality objective that is far more restrictive than ambient water concentrations. While the Regional Board staff mechanically implemented the US EPA guidance on using the water effects ratios approach for developing the site-specific objective, those knowledgeable in aquatic chemistry and aquatic toxicology know that the US EPA's approach does not properly consider

the forms of contaminants in the inputs or their impacts on the beneficial uses of the waterbody. This issue was discussed in the general comments above.

On page 2, paragraph 2 (Part 1) the statement is made,
"The mass-based approach is proposed as an amendment to the Basin Plan. The reduction of mass loading is proposed as the most effective way to reduce the widespread exceedances of the copper objective that have been measured in most parts of the estuary."

As indicated above, the basic premise for this approach is flawed. The issue should not be attainment of an overly protective objective, but should be the protection of designated beneficial uses of San Francisco Bay. Failure to focus the control of copper on that issue will ultimately lead to massive waste of public and private funds. Many tens to hundreds of millions of dollars will be wasted if the Regional Board staff's proposed approach is adopted and implemented. As noted above, the reductions of external copper load will not effect the meeting of the water quality objective applied as it is to total concentrations of copper. There is no demonstration of a water quality problem caused by the current discharges of copper. Requiring the reduction of copper in point and non-point sources including stormwater runoff, in a futile effort to prevent administrative exceedances of an inappropriate objective cannot be considered to be appropriate, especially given the financial conditions that exist in the State today and that will exist in the future. Funds used for pollution control should be directed to solving real water quality problems, and not artifacts of administrative exceedances of inappropriate objectives.

The first paragraph on page 3 (Part 1) states,
"According to federal regulations, 'WLAs/LAs and TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numerical WQS (water quality standard) ...'"

Attainment of this objective requires an understanding of the relationship between the discharges of copper to the Bay and the concentrations they cause to remain in the watercolumn separate from the concentrations in the watercolumn that are derived from the sediments. As discussed below, the Regional Board staff does not have such an understanding. The amounts of copper proposed to be controlled and the distribution of the allocated loads were arbitrarily selected. Municipalities, industries and others should not be forced to develop treatment works to provide for removal of copper to some arbitrary level, and then subsequently to adjust that level again, and again, as the staff tries by trial and error to achieve the 4.9 μg/L objective in the Bay. When treatment works are developed it is important to have a good understanding of the ultimate goal to be achieved, and of the ability to achieve that goal. Clearly this aspect of the economic ramifications of the proposed approach has not been considered in the draft staff report.

Furthermore, the draft staff report has not addressed the ramifications of antibacksliding and antidegradation requirements. If permits are issued requiring a discharger to meet certain effluent limitations, but at some time in the future when the error in the approach for establishing the wasteload allocations becomes recognized and the discharge limitations are increased, this could be seen by some as a "relaxation" of protection and "backsliding" leading to degradation. The permittees could then become involved in issues of antidegradation and antibacksliding. Certainly this issue needs to be fully discussed in any proposal to establish what are arbitrary

TMDL's (total maximum daily loads) such as those incorporated into the proposed wasteload allocation.

The Board and its staff need to recognize and then incorporate principles of the aqueous environmental chemistry and aquatic toxicology of copper into the decision-making process on controlling copper input to the Bay. Those principles and findings in practice have been largely lacking in the processes that have been used thus far. This lack of proper utilization of aquatic chemistry in the decision-making process will certainly lead to massive waste of public and private funds in unnecessarily controlling contaminants to achieve arbitrarily establish levels selected by the Regional Board staff.

This problem is also reflected in paragraph 4 of page 3 which states,
"However, in many cases available data are not sufficient to support a model that can predict a TMDL. In these cases, TMDLs may be developed using a phased approach, where initial reductions in loading are required based on available information, and water quality monitoring is used as a feedback mechanism to determine whether loading reductions have been adequate to attain standards."

Rather than going ahead with developing TMDL's, the staff should focus on developing the data necessary to develop a predictive model to reliably determine the effect of a load reduction on beneficial uses of the Bay. The so-called phased approach is arbitrary and will certainly lead to inappropriate control of copper loads that have nothing to do with existing or potential water quality problems due to copper in the Bay and estuary. While some may assert that the phased approach must be followed because it is in accord with US EPA recommendations, the US EPA recommendation cannot be considered technically supportable. If the US EPA is forcing a phased approach on point-source and non-point-source dischargers to San Francisco Bay and its tributaries especially under the existing condition where the only "problem" that exists is the administrative exceedance of an overly protective water quality objective, its policy should be challenged in the courts. As discussed in these comments, over the past decade the US EPA has made some serious errors in its approaches and policies for developing control programs for potentially toxic contaminants in the Nation's waters. This would be another example of such an inappropriate policy.

On page 3 (Part 1), under the "no action" Alternative 1, the staff attempts to justify its use of an arbitrary approach for establishing copper control requirements on the basis of the fact that the approach would allow it to control riverine and stormwater sources (rather than only the sources currently regulated) that it feels are the most significant contributions of copper to the system. Again, the staff has not made a proper analysis of the situation. Based on my discussions with members of the Central Valley Regional Water Quality Control Board and the staff, there is little possibility of significantly controlling copper from the Sacramento-San Joaquin River system beyond that which is already being done or anticipated. Much of this riverine copper is derived from stormwater and mine drainage within the Sacramento-San Joaquin River system. The mine drainage is derived from abandoned mines. If there were a readily implementable approach to control the copper discharged from those abandoned mines, it would have already been implemented.

With respect to stormwater sources of copper, there are significant legal questions about whether it is appropriate for the San Francisco Bay Regional Board to establish discharge limits on stormwater-associated copper both within the region and within riverine sources that contribute copper to the Bay and estuary such as the city of Sacramento an other municipalities whose stormwater runs off to the Sacramento-San Joaquin River system. The State Water Resources Control Board stormwater control program provides a 10-year exemption before stormwater-associated contaminants must meet water quality objectives in the receiving waters. This is justified based on the fact that the water quality objectives in the receiving waters are well-recognized to be overly protective of receiving water beneficial uses and on the nature of stormwater discharges. The State Water Resources Control Board's Stormwater Quality Task Force is highly involved at this time in developing revisions of the Clean Water Act so that stormwater-associated contaminants such as copper would be exempted from meeting water quality standards (objectives) of the type that the Regional Board has adopted for San Francisco Bay. Those objectives, as noted above, are applied to total concentrations of contaminants and do not properly reflect the episodic nature of stormwater discharges. Their application to total contaminants is well-recognized to be highly overly restrictive for the protection of designated beneficial uses and will lead to waste of public and private funds in controlling contaminants associated with stormwater runoff.

At the San Francisco Bay Regional Water Quality Control Board hearing at which Mr. Ritchie presented the wasteload allocation approach to the Board, a member of the Board commented that it may be necessary to issue the Central Valley Regional Water Quality Control Board an NPDES permit for copper to force that Board to control copper from upstream sources. There can be no doubt that the proposed action by the San Francisco Bay Regional Board will lead to litigation among a variety of parties and possibly between regional boards. There will likely be little sympathy in the courts for the highly overly protective approach of the San Francisco Bay Regional Board that does not properly consider the aqueous environmental chemistry of copper especially when it is realized that the San Francisco Bay Regional Board has yet to find a real water quality problem in San Francisco Bay that is caused by copper. I believe this will cause the courts to question the wisdom of and need for forcing the public in the San Francisco Bay Regional Board jurisdiction and the Central Valley Regional Board's area of jurisdiction, to control copper to try to prevent administrative exceedances of water quality objectives that are overly restrictive for the protection of designated beneficial uses of the Bay.

The discussion of alternatives 2, 3 and 4 on page 4 (Part 1) presents various strategies for selecting sources of copper that should be controlled. That discussion, again, shows the lack of consideration of the principles of the aqueous environmental chemistry of copper. It presumes that all copper from all sources has equal impact on the concentrations of copper in the watercolumn in San Francisco Bay as well as on designated beneficial uses of the Bay. It also ignores the fact that adverse impacts on designated beneficial uses of the Bay have not been found to occur with the current loading of copper to the Bay. Those familiar with the aqueous environmental chemistry of copper know that different forms of copper are present in different sources, and that while they may be similar in concentration (as measured in "total recoverable" procedures), the various sources can have significantly different toxicities. In fact, however, very few of the sources of copper contain forms that have the potential to be adverse to aquatic

life and other beneficial uses. The public in the San Francisco Bay area, as well as in the state as a whole, is entitled to a more enlightened approach than that demonstrated in the recommended wasteload allocation.

A review of the alternatives presented in the draft staff report for the Board's consideration shows that the most important alternative that the Board should consider has not been addressed, namely the application of the wasteload allocation approach to dissolved copper. As discussed above and in previous correspondence submitted to the State and Regional Boards, it has been known for more than 20 years that "total recoverable" copper greatly overestimates the concentrations of toxic forms of copper. For a number of years now, the US EPA has been allowing states to implement the US EPA water quality criteria for heavy metals including copper, based on dissolved forms in ambient water. Sixteen states have already adopted that approach, and many more will follow when the discussions at the Annapolis workshop become well-known. This issue was also discussed at a State Board workshop on November 23, 1992, and in my opinion, there can be little doubt that ultimately the state of California will adopt this approach as well. Therefore, I believe that it is a significant deficiency of the draft wasteload allocation for copper that it does not discuss the implications on the proposed allocation of the application of objectives to "dissolved" copper. The staff should prepare a detailed discussion of this issue for public review as part of its consideration of alternatives.

Beginning on page 7 (Part 1), and continuing through page 16, various tables were presented of proposed "total maximum daily load for copper" for various copper sources to the Bay. Part 2 of the proposed "Wasteload Allocation for Copper for San Francisco Bay" discussed how those values were developed. The values are arbitrary and without technical foundation. Further, there is no possibility that the achievement of the proposed load allocations by each source would result in the meeting of the 4.9 µg/L water quality objective applied to total recoverable forms as proposed.

On page 31 of Part 2 of the draft staff report, it was acknowledged,
"The single greatest source of uncertainty is the role of suspended sediments as either a source or sink of copper to the water column."

As discussed above, it is the sediment component that renders the approach being followed by the staff unreliable and arbitrary. What is reported to be the purpose of the wasteload allocation is the achievement of an objective in the watercolumn. Since very small amounts of sediments stirred into the watercolumn can cause "exceedances" of the objective applied to "total recoverable" forms, it is mandatory that before any wasteload allocation is imposed, a good understanding of the role sediments play in causing exceedances of the objective be obtained. Otherwise, hundreds of millions of dollars could be spent trying to achieve an unachievable objective through the wasteload allocation process.

Appendix 2-A of Part 2 discusses the current status of the staff's attempts to model the behavior of copper in San Francisco Bay. Based on the information provided, the staff does not have a reliable model upon which to base wasteload allocation. One of the primary reasons cited by the staff for not having a reliable model is the inability to describe the interaction of copper with the sediments of the Bay. It is clear that the staff should not be recommending wasteload allocations

at this time because of the lack of reliable information on the relationships between loads from various sources and their impacts on the concentrations of copper in the watercolumn that cause exceedances of the water quality objective, much less those that cause adverse impacts on the beneficial uses of the Bay. The recommended approach in the draft staff report is in clear violation of the provisions of the Porter-Cologne Act which requires consideration of economic factors in implementing basin plans and their objectives.

In Part 2 the staff mentioned its use of hydraulic residence time in the development of wasteload allocation values (see pages 22 - 24). The key issue is not the hydraulic residence time but rather chemical (copper) residence time. It is the residence time of copper in the watercolumn that determines the concentration of copper, which in turn, serves as the basis for determining whether the proposed wasteload allocations for copper load will achieve the objective. This is yet another fundamental technical flaw in the development of the wasteload allocations.

From an overall perspective, a review of Part 2 of the staff's draft report could lead someone not familiar the technical foundation for the discussion presented to believe that the staff's proposed wasteload allocation has some technical validity. For the reasons discussed herein, a proper peer review of these issues by those knowledgeable in aquatic chemistry, aquatic toxicology, and the impact of copper on beneficial uses of waterbodies would show that the proposed wasteload allocation is arbitrary and without technical foundation.

Recommendations

It is our recommendation that the Board not adopt the staff's recommended first phase copper load limitations for San Francisco Bay or the proposed wasteload allocation. They were arbitrarily developed, without technical foundation, and are contrary to the technical information available today regarding the water quality significance of copper.

We recommend that the Board instruct the staff to begin work on developing a proper assessment of whether there are now exceedances of the 4.9 μg/L objective based on dissolved forms of copper, properly measured, in the Bay waters. This will require the use of reliable analytical techniques that reliably sample, separate dissolved from particulate forms, and measure the forms in true solution. If "exceedances" are found, studies should be initiated to determine whether the exceedances cause significant adverse impacts on beneficial uses of the waters of the Bay, i.e., real water quality problems. If real water quality problems are found to be due to copper, the development of the studies to define the relationship between the loads of copper from each source to the Bay and its tributaries and the concentrations of copper in the Bay water that are adverse to aquatic life residing in the Bay. At that time, a total mass emissions strategy control limit for the Bay can be developed and a reliable wasteload allocation can be formulated to focus on controlling copper from those sources that are specifically responsible for the adverse impacts on the beneficial uses of the Bay. The recommended approach is the technically valid, cost-effective approach that should be adopted by the Board. It properly reflects the technical information available today and clearly is in the best interest of the people of the State.

Concluding Remarks

As were our previous comments on the site-specific objectives for San Francisco Bay, these comments were made on behalf of the people of California. If the members of the Board wish to have additional information on any of the issues discussed in this letter, or wish to have us provide copies of any of the citations made in this letter, please contact me. Again, if there is interest in discussing with me the technical issues pertinent to the development of technically valid, cost-effective approaches for evaluating the water quality significance of copper in or added to San Francisco Bay, please let me know. I would be happy to meet with you, or other members of the Board to discuss these issues.

We fully appreciate the significant problems that the Regional Board and its staff face owing to funding limitations for its activities in implementing legislative requirements, and to inappropriate regulations imposed. However, such limitations should not be considered to provide justification for adopting what are obviously technically invalid approaches or approaches that do not use the best technical information available for the formulation of evaluation and management programs for contaminants in the Bay's waters. We are sufficiently concerned about developing technically valid, cost-effective approaches for evaluating and managing contaminants in the Bay's waters to provide the Regional Board with our expertise and experience in this area as we can.

If the Board, staff, or others dispute the technical information or positions reflected in these comments, we request that the point(s) of contention be articulated and substantiated in writing for our review and comment in accord with standard professional peer review approaches.

Sincerely yours,

G. Fred Lee, Ph.D., D.E.E., President

cc: Other Members of San Francisco Regional Water Quality Control Board
S. Ritchie
J. Lacy
E. Samaniego
Other Members of the State Water Resources Control Board
W. Pettit

References

Lee, G. F., "Analytical Chemistry for Plant Nutrients," Proc. Symposium on Eutrophication, Madison, WI, National Academy of Science, pp. 646-658 (1969).

Lee, G. F., "Comments on Final Draft Pollutant Policy Document for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary," Report of G. Fred Lee & Associates, El Macero, CA, Submitted to the Water Resources Control Board, June (1990).

Lee, G. F., Comments on Site-Specific Water Quality Objectives for Copper in San Francisco Bay, Letter to M. Otsea, Chairman San Francisco Bay Regional Water Quality Control Board, October 19 (1992a).

Lee, G. F., Comments on Site-Specific Water Quality Objectives for Copper in San Francisco Bay, Letter to M. Otsea, Chairman San Francisco Bay Regional Water Quality Control Board, October 25 (1992b).

Lee, G. F., and Jones, R. A., "Assessment of the Degree of Treatment Required for Toxic Wastewater Effluents," Proc. International Conference on Innovative Biological Treatment of Toxic Wastewaters, US Army Construction Engineering Research Laboratory, Champaign, IL, pp. 652-677 (1987).

Lee, G. F., and Jones, R. A., "'Contaminant' vs. 'Pollutant:' Need for Consideration in US EPA and State Pollution Control Agency Policy in Developing Control Programs for Aquatic Life Toxicity," Report of G. Fred Lee & Associates, El Macero, CA, October (1990a).

Lee, G. F., and Jones, R. A., "Comments on Draft Statewide Water Quality Control Plans for: (1) Inland Surface Waters of California (California Inland Surface Waters Plan); 2) Enclosed Bays and Estuaries of California (California Enclosed Bays and Estuaries Plan) Dated November 2, 1990 and Functional Equivalent Document dated November 26, 1990," Report of G. Fred Lee & Associates, El Macero, CA, Submitted to the California Water Resources Control Board, December (1990b).

Lee, G. F., and Jones, R. A., "Comments on US EPA's November 19, 1991 Proposed Rule for Compliance with Water Quality Standards Regulations Governing State Development of Numeric Water Quality Standards for Toxic Chemicals," Submitted to US EPA, Washington, D.C., G. Fred Lee & Associates, El Macero, CA, December (1991).

Lee, G. F., and Jones-Lee, A., "Perspectives on Appropriate Goals for the Control of Toxic Chemicals in Aquatic Systems with Particular Reference to Non-Point Source Pollution," Report of G. Fred Lee & Associates, El Macero, CA, July (1992a).

Lee, G. F., and Jones, R. A., "Sediment Quality Criteria Development: Technical Difficulties with Current Approaches, and Suggested Alternatives," Report of G. Fred Lee & Associates, El Macero, CA, January (1992). Condensed version published as: Lee, G. F., and Jones, R. A., "Sediment Quality Criteria Development: Technical Difficulties with Current Approaches, and Suggested Alternatives (Condensed Version)," IN: Proc. HMCRI R&D 92 Conference on the Control of Hazardous Materials, HMCRI, Greenbelt, MD, pp. 204-211 (1992).

Lee, G. F., and Jones-Lee, A., Comments on Draft Staff Report, 'Criteria to Rank Toxic Hot Spots in Enclosed Bays and Estuaries of California,' State Water Resources Control Board Draft Staff Report, IN: Letter to E. Samaniego, Vice-Chairman California Water Resources Control Board, from G. Fred Lee, January 23 (1993a).

Lee, G. F., and Jones-Lee, A., Comments on Draft Staff Report, 'Criteria to Rank Toxic Hot Spots in Enclosed Bays and Estuaries of California,' State Water Resources Control Board Draft Staff Report, IN: Letter to E. Samaniego, Vice-Chairman California Water Resources Control Board, from G. Fred Lee, February 1 (1993b).

NAS/NAE (National Academy of Science and National Academy of Engineering), Water Quality Criteria - 1972, EPA-R3-73-033, US Government Printing Office, Washington, D.C., March (1973).

US EPA, Quality Criteria for Water, EPA 400/9-76-023, US EPA, Washington, D.C. (1976).
Wiersma, J., and Lee, G. F., "Selenium in Lake Sediments-Analytical Procedure and Preliminary Results," Environ. Sci. & Technol. 5:1203-1206 (1971).

Suggested Formulation of Waste Load Allocation for Copper in San Francisco Bay

G. Fred Lee, Ph.D., D.E.E.

- Identify a Real Water Quality Problem (Impairment of a Designated Beneficial Use) in San Francisco Bay That Is Caused by Copper

- Develop an Applicable Water Quality Objective to Eliminate the Impairment of Designated Beneficial Use without Unnecessary Contaminant Control

- Determine the Role That Copper Sources to the Bay Play in Contributing to the Beneficial-Use Impairment

- Determine the Necessary Reduction in Copper Load from Each Source Currently Contributing to the Use-Impairment Needed to Eliminate the Problem

Proposed Approach Has Faulty Technical Foundation

- No Water Quality Problem Identified - "Administrative Exceedance of Objective"

- Site-Specific Copper Objective of 4.9 µg/L Overly Protective

- No Relationship Developed between Copper Sources and Concentrations of Copper in Watercolumn
    - Sediment Contribution of Copper Not Considered
    - Resuspension of Sediment-Associated Copper Will Preclude Attainment of Numeric Copper Objective in Watercolumn

- Proposed Waste Load Allocation Arbitrary

    - Phased Approach Will Result in Massive Waste of Public and Private Funds

- Proposed Approach Failed to Consider Dissolved Copper Objective
    - "Administrative Exceedance" of Objective Disappears

- Do Not Adopt Proposed Waste Load Allocation for Copper

San Francisco Bay as a Toxic Hot Spot

G. Fred Lee, PhD, DEE
G. Fred Lee & Associates
El Macero, CA 95618-1005

March 13, 1995

The work that has been done thus far in San Francisco Bay today provides an excellent opportunity to evaluate the development of the Bay Protection and Toxic Cleanup Program's (BPTCP) approach for designating toxic hot spots in the state's waters. A summary of key issues is presented below.

- The concentrations of several heavy metals including copper and nickel have been found to exceed water quality objectives in the Bay waters.

- Extensive testing of San Francisco Bay waters during 1993 has shown that these waters are non-toxic to three different types of sensitive organisms (Thompson et al. 1994).

This means that the exceedance of the water quality objectives for copper reflects the inappropriate approach that was used to develop the water quality objectives rather than a real use impairment of San Francisco Bay waters (Lee and Jones-Lee 1995).

- Several species of fish taken from the Bay waters have been found to have excessive concentrations of several chemicals (PCB's, Hg, Dieldrin, Chlordane, DDT and Dioxins), compared to those that are considered acceptable for human consumption (SFRWQCB et al. 1994).

This means that a real use impairment of San Francisco Bay waters is occurring since the use of these fish as food is considered by current standards to be hazardous to public health.

- Studies on the chemical characteristics of San Francisco Bay sediments generally show that it would be highly unlikely that the measured constituents (selected heavy metals Cr, Zn, Co, Ni, V, Cu, Cd, Pb, Ag and organics PAH's, PCB's, PCT, DDT, Chlordane and HCH) in sediments are significantly adverse to the designated beneficial uses of San Francisco Bay waters. The studies on the sediment pore water chemical constituents did not yield interpretable results except to say that the concentrations in the pore waters, based on the techniques used for many constituents, appear to be very low.

- No work has apparently been done thus far to use acid volatile sulfide normalization of heavy metal data to rule out potential toxicity due to heavy metals, as well as TOC normalization to rule out toxicity due to certain organics that tend to partition with the organic carbon in the sediments.

- Measurements of toxicity in San Francisco Bay sediments using several sensitive organisms (oyster and fish larvae, marine and fresh-water amphipods, Daphnia, sea urchin fertilization, salmonella and nematodes) show that the sediments at some locations are "toxic" under the conditions of the test. Toxicity studies on "reference" sediment also showed significant toxicity to some organisms. Further, some of the toxicity to the amphipods appears to be due to grain size and not chemical characteristics of the sediments.

- Studies on the use of certain biomarkers associated with sea urchins, nematodes and salmonella apparently show organism exposure to chemicals that cause the response. At this time, these results are uninterpretable in terms of the water quality - beneficial use significance of the biomarker response and will likely remain that way for many years.

- No TIE work has apparently been done thus far which demonstrates the cause of the sediment toxicity that has been found.

- The Draft FED (WRCB 1995) lists San Francisco Bay waters as a "candidate toxic hot spot." Previously, the BPTCB staff (BPTCP 1993) have listed parts of San Francisco Bay as known or potential toxic hot spots based on exceedance of water quality objectives, sediment toxicity and organism tissue levels. The chemicals that are specifically listed as being responsible for these designations include Ag, Cd, Cr, Cu, Hg, Pb, Zn, DDT, PAH's, PCB's, TBT, chlordane, dieldrin, aldrin, and endrin.

Conclusions

Therefore, there is a real use impairment of San Francisco Bay waters due to the excessive bioaccumulation of certain chemicals in fish tissue. There does not appear to be a major point-source input of the chemicals that are bioaccumulating to excessive concentrations in San Francisco Bay fish. Since several and possibly all of the chemicals that are bioaccumulating in fish tissue are derived from sediment sources, it will be necessary to determine the specific locations in San Francisco Bay and tributary sediments, if there are any, that serve as the primary source(s) of the chemicals that are bioaccumulating in the fish tissue. This will likely require a major research effort involving many years of work.

The exceedance of the water quality objectives for copper and nickel are not valid criteria for designating San Francisco Bay as a toxic hot spot since there is no toxicity in the water column due to these or other chemicals. It is important to note that the finding of toxicity in the sediments of San Francisco Bay should not be used as justification to claim that the exceedances of the water quality objective by copper in the Bay waters represents a use impairment of San Francisco Bay. The concentrations of copper reported in San Francisco Bay sediments are likely well below any concentration that would be considered adverse to aquatic life. It therefore appears, from the data available now, that all efforts towards controlling copper inputs to San Francisco Bay should be immediately terminated since no water quality problems have been found nor would there likely be water quality problems associated with the so-called excessive concentrations of copper in San Francisco Bay waters.

The toxicity found in sediments is of unknown significance to the impairment of the designated beneficial uses of San Francisco Bay. It does not appear to be related to any specific chemical. It could be due to unregulated chemicals. Since many aquatic sediments show toxicity to aquatic life that have excellent aquatic life resources associated with them, before San Francisco Bay should be justifiably listed as a toxic hot spot due to sediment toxicity, a major research effort will have to be undertaken to determine the cause of the sediment toxicity, and most importantly, its significance to the designated beneficial uses of San Francisco Bay waters.
Since it is not possible to specifically delineate the sources of the chemical constituents that are causing the excessive accumulation of certain chemicals in San Francisco Bay fish and since the cause and water quality use impairment significance of sediment toxicity is unknown, questions can be raised as to whether San Francisco Bay should be listed as a toxic hot spot in light of the currently proposed definitions for toxic hot spots presented in the Draft FED (WRCB 1995). Further, if it is, what steps can and should be taken to investigate - remediate this situation? These are issues that need to be considered as part of developing a toxic hot spot designation approach in the BPTCP.

The above information is based on reports provided by BPTCP investigators. At this time, the reliability of the data provided in these reports has not been evaluated. Further, there may be additional information that has not yet been made public which could be of importance in formulating an assessment of the current designation of San Francisco Bay as a toxic hot spot.

References

BPTCP, "Status of the Bay Protection and Toxic Cleanup Program," Staff Report Bay Protection and Toxic Cleanup Program, State Water Resources Control Board, Sacramento, November (1993).

Flegal, A. Russell, R. W. Risebrough, B. Anderson, J. Hunt, S. Anderson, J. Oliver, M. Stephenson and R. Packard, "San Francisco Estuary Pilot Regional Monitoring Program: Sediment Studies," Final Report Submitted to San Francisco Bay Regional Water Quality Control Board and State Water Resources Control Board July (1994).

Lee, G. Fred, and Jones-Lee, Anne, "Appropriate Use of Numeric Chemical Concentration-Based Water Quality Criteria," Accepted for publication in Health and Ecological Risk Assessment (1995).

SFRWQCB et al., "Contaminant Levels in Fish Tissue from San Francisco Bay," San Francisco Regional Water Quality Control Board, State Water Resources Control Board and California Department of Fish and Game, Final Draft Report, December (1994).

Thompson, B., Hunt, J., Hansen, R., Gunther, A. and Hardin, D., "Toxicity and Bioaccumulation Results from the 1993 Regional Monitoring Program," Presentation at the NorCal Regional Chapter for Environmental Toxicology and Chemistry Fourth Annual Meeting, Oakland, CA, May (1994).

WRCB, "Functional Equivalent Document: Development of the Water Quality Control Policy for Implementation of the Bay Protection and Toxic Cleanup Program" Draft, State Water Resources Control Board, Division of Water Quality, January (1995).