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September 14, 1996

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Dear Val:

I wish to follow upon the last Sacramento River Watershed Toxics Control Program Toxics Subcommittee meeting to provide additional discussion on the appropriateness of using surrogate test organisms such as fathead minnow larvae, *Ceriodaphnia*, and algae to indicate potential toxicity to various forms of aquatic life in the Sacramento River system. As you know there are some individuals who claim that toxicity testing using surrogate organisms is not reliable; the only reliable approach is to use resident species. Since statements of this type were made at our Subcommittee meeting, I felt it was important to summarize the current status of what is known today in the water pollution control field about the reliability of the use of indicator species as a test organism for water pollution control programs designed to control toxicity in ambient waters. As discussed below, claims that indicator species are not reliable are not in accord with what is generally known today about the reliability of the US EPA's standard test organism to detect potentially significant toxicity in ambient waters.

For the past couple of years there has been considerable discussion of this issue in an attempt by some wastewater dischargers to discredit whole effluent toxicity testing (WET) as an appropriate regulatory tool. This has caused several groups and individuals to develop reviews on this topic. Approximately one year ago, de Vlaming (1995a,b) of the California Water Resources Control Board staff conducted a comprehensive review of the reliability of toxicity testing using acute/chronic tests in predicting water quality use impairments that are manifested as impaired aquatic organism populations. There are many situations where chemical composition of waters in which potentially toxic elements exceed US EPA water quality criteria do not reliably predict the water quality impacts in the receiving water for a wastewater discharge. Further, there are also many situations where attempting to estimate toxicity based on the regulated potential toxicants such as heavy metals do not detect toxicity due to the unregulated chemicals such as the organophosphorus pesticides. These types of situations have led to the development of whole effluent toxicity tests.

de Vlaming (1995a,b) reported that toxicity measurements on an effluent have been found to predict biological community impacts in the receiving waters for the effluent about 70% of the time. The reliability of the toxicity tests for estimating in-stream biological responses was improved when toxicity tests were conducted with ambient water and when the exposure conditions that organisms would experience in the ambient waters were duplicated in the toxicity test.

Overall, de Vlaming concludes that the

*"Available literature yields a compelling, weight of evidence, demonstration that the WET, and other indicator species, toxicity test results are accurate qualitative predictors of instream biological community responses."*

de Vlaming also indicated that in August 1995 the Society for Environmental Toxicology and Chemistry held a "Pellston" workshop devoted to the reliability of effluent toxicity tests in predicting water quality impacts in receiving waters. The participants in the workshop were experts in this field. While the proceedings of this workshop will not be published until the fall 1996, according to Denton (1995), the workshop participants came to the same conclusion as de Vlaming on the reliability of toxicity tests using surrogate test organisms in predicting biological community impacts.

Over the years I have found that the dischargers/polluters who want to discharge unregulated toxic chemicals such as some of the pesticides object to ambient water toxicity measurements. This is the situation that is being encountered with diazinon. However, toxicity measurements of diazinon toxicity to *Ceriodaphnia* are far more reliable in detecting potentially toxic conditions than chemical measurements of diazinon and the use of a chemical concentration-based numeric value to predict toxicity.

de Vlaming's review provides considerable support for the use of ambient water toxicity tests in which multiple species short-term chronic toxicity tests are used on ambient waters. It can be expected that if toxicity that persists in the receiving waters is found under these conditions, that there would be adverse impacts on the biological populations in these waters. Under these conditions the specific cause of this toxicity should be identified through a Toxicity Investigation Evaluation (TIE). Further, the source of the toxicity needs to be identified and programs should be implemented to control it.

While testing with surrogate organisms does not predict the exact magnitude of toxicity that would be expected for other forms of aquatic life in a waterbody, it does, especially if conducted on ambient waters, provide a high degree of protection from potential adverse impacts on aquatic life populations due to aquatic life toxicity without significant overprotection.

One of the issues of concern in any aquatic life toxicity testing program is the interpretation of toxicity measurement results on wastewater discharges and/or stormwater or agricultural water runoff/discharges. Basically the issue is whether it is possible to translate standard test organism toxicity responses on input waters to ambient water conditions. In my previous correspondence, I have provided information on what Dr. Jones-Lee and I call the evaluation monitoring approach. This approach focuses on assessing toxicity in the receiving waters for the stormwater runoff from a particular area or some other source. Rather than measuring heavy metals in runoff which are of importance because of their potential aquatic life toxicity in the receiving waters, toxicity in the receiving waters is measured before, during and after a stormwater runoff event. Last June, Dr. Jones-Lee and I presented a paper entitled "Assessing Water Quality Impacts of Stormwater Runoff" at the American Society of Civil Engineers North American Water & Environment Congress conference. This paper is published on CD-ROM in the proceedings of this conference. A hard copy of the paper is available from me upon request. It specifically discusses the use of toxicity tests in the evaluation monitoring approach for determining whether toxicants in runoff waters are causing significant aquatic life toxicity/use impairment in the receiving waters for the runoff.

Measurement of toxicity in the runoff waters does not necessarily translate into significant toxicity in the receiving waters for the runoff. Caution should be exercised in assuming that the toxicity measured in runoff waters results in significant toxicity in the receiving waters for the runoff that leads to an impairment of the designated beneficial uses. The US EPA (1991) in the Agency guidance for implementing the WET test results states,

> *"The regulatory authority must carefully look at the test protocols and all the data collected to determine if the facility is actually contributing to toxicity in the ambient water."*

It is therefore important to determine whether toxicity in a particular input water to an aquatic system translates to significant toxicity in the receiving (ambient) waters for the discharge/runoff.

In summary, aquatic life toxicity testing using *Ceriodaphnia*, fathead minnow or trout larvae is a reliable tool to indicate potential toxicity that needs to be investigated further to determine whether the organisms of interest at a location and downstream thereof are being significantly adversely impacted by toxicants. Such testing is far more reliable for detecting potentially significant toxicity situations than the use of chemical measurements where there is an attempt to extrapolate from the chemical measurement to aquatic life toxicity. It has been found that screening for aquatic life toxicity using the US EPA's three species is the most reliable tool available and it is sufficiently reliable to detect potentially significant aquatic life toxicity situations, especially when conducted on ambient waters.

The one aspect of the three species test that is of concern to me is the use of algae as a test organism. While I recommend the use of algae as a test species, there are, however, potentially significant problems interpreting algal toxicity data. I have developed a review of this topic as "Planktonic Algal Toxicity Testing in Regulating Point and Non-point Discharges and Its Implications for Use of Dissolved Metal Criteria/Standards." This review has been submitted for publication. Basically, the problem is that in most situations considerable efforts are made to control algae because of their nuisance and other impacts associated with excessive growth-eutrophication. Further, the toxic action on algae is significantly different from that on fish or zooplankton. With algae it tends to be a stasis (inhibition of growth) for the time that the toxicant is present in sufficient concentrations. However, eventually, due to a variety of mechanisms the toxicity is lost and the algae start to grow again.

While there are some who claim that inhibiting algal growth can be adverse to the whole food web, it is clear that inhibition has to be present for considerable periods of time and to a sufficient extent before there is any significant adverse impact on the numbers and types of fish present in a waterbody. Several years ago, Dr. Jones-Lee and I published a paper entitled, "Effects of Eutrophication on Fisheries," Reviews in Aquatic Sciences 5:287-305, CRC Press, Boca Raton, FL (1991), which quantifies the relationship between algal biomass and fish biomass in waterbodies. Quite large changes in algal biomass have to occur before fish biomass is significantly impacted. Another factor to consider in interpreting algal toxicity tests is that the conditions of the algal toxicity tests are significantly different than those that occur in ambient waters. This situation distorts the meaningfulness of an algal test as a reliable indicator of potential water quality problems for aquatic plants.

It is important to understand that I do not recommend aquatic life toxicity testing as a pass/fail situation where if toxicity is found in the laboratory tests, that this necessarily means that significant toxicity will be occurring in ambient waters. From the information available, it is fairly clear that there will likely be toxic effects in ambient waters if toxicity is found in laboratory conditions provided that the duration of exposure toxicity persistence relationship that occurs in the ambient waters is mimicked in the laboratory test. Whether these effects are significant to the public or not needs further investigation. This can best be done by properly conducted biological assessments. Again, I want to emphasize that the alternative approach for regulating potentially toxic metals or other potentially toxic regulated chemicals of basing the estimates of toxicity on chemical concentrations is far less reliable than the direct toxicity measurements. Further, the toxicity measurements are the only way now to address the unregulated chemicals.

In conclusion, ambient water toxicity measurements have been sufficiently well developed and evaluated today to serve as reliable tools for determining whether potentially significant toxicity is present in a waterbody or its tributaries. The Sacramento River Watershed Toxics Control Program, if it is to be reliable in achieving the objectives of defining what toxicity is present and working with the stakeholders in developing technically valid, cost effective control programs for this toxicity, must focus primarily on ambient water toxicity measurements of the type that the UC-Davis group proposes to use in the initial screening of toxicity in the Sacramento River system.

The Toxicity Monitoring Program that has been outlined by UCD is a good initial start to provide data that are necessary for the Sacramento River Watershed Toxics Control Program. The initial program outlined in our recent subcommittee meeting should be the first phase of what will ultimately need to be a significantly expanded program in aquatic life toxicity measurements in the Sacramento River watershed. The proposed sampling stations and frequency of sampling appear to be satisfactory based on the funds available for the initial phase of the toxicity measurements.





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It should be understood that it will likely become necessary to significantly expand the toxicity measurements and, in particular, take samples at times that reflect possible worst-case conditions in terms of toxicity discharges to the Sacramento River system from various types of agricultural activities such as after application of pesticides, urban runoff, runoff from mining areas and mined wastes and wastewater discharges from domestic and industrial sources. As you know, certain types of activities such as the use of diazinon in orchards as a dormant spray result in short periods of high intensity toxicity in rainfall and runoff waters in Northern California. It is therefore necessary to sample particular runoff events at certain times in order to determine the magnitude of the toxicity that is occurring. A routine sampling program of the type that is outlined in the initial studies could totally miss significant toxicity that would be highly detrimental to fish and other aquatic life by failing to sample during a specific time when runoff and airborne transport of diazinon occur from the orchards shortly after its application each winter.

It will also be necessary to conduct studies with a more in-depth-comprehensive nature at certain locations where toxicity is found in order to determine the duration and areal extent of toxicity. This would require special studies that focus on intensive sampling around the runoff/discharge event. While this type of sampling is not traditionally done in routine monitoring programs, it is necessary if meaningful data are to be developed. The periodic, mechanical sampling at certain locations and certain times is often of limited value in defining real water quality issues.

It is important not to lose sight of why the Sacramento River Watershed Toxics Control Program studies are being conducted, namely to determine what toxicity exists in this system, the significance of this toxicity to the beneficial uses of the water within the system and downstream and the development of technically valid, cost-effective programs to control the toxicity to a sufficient degree to protect the designated beneficial uses of the Sacramento River watershed, its tributaries and the downstream users of the waters from this system. In order to achieve these objectives, a substantial part of the monitoring efforts during the next few years should be devoted to toxicity measurements.

I want to emphasize that chemical measurements of the traditional monitoring type for heavy metals and certain organics that are of concern because of potential toxicity should be given a lower priority for funding than toxicity measurements. The chemical measurements do not reliably estimate toxicity. The chemical measurements should be used as support to toxicity measurements to determine what possibly could cause the measured toxicity and help to some extent to trace the source of the toxicity, although again toxicity measurements will have to be used in a forensic manner to determine the sources. In connection with the areal extent, intensity and duration toxicity studies, it will likely be necessary to conduct some follow-on toxicity tests in which the duration of exposure in the toxicity tests is designed to match the duration of exposure/dilution in the receiving waters for the toxic discharges/runoff.

Further, where potentially significant toxicity is found, work will need to be done to identify the cause of toxicity through specialized TIEs. These studies should not be conducted as mechanical TIEs, but should be designed to identify quickly those problems that are likely to cause toxicity depending on the source. There may be situations where it is not possible to identify the specific cause of toxicity; however, it can be traced back to a source through toxicity measurements used in a





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forensic manner. It is possible to develop toxicity control programs even though the toxicants responsible are never identified.

If there are any questions on these comments please contact me and please feel free to make them available to others who may be interested in this topic.

Sincerely yours,

G. Fred Lee, PhD, DEE

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Copies of the above listed Lee and Jones-Lee papers are available upon request.





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