UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON D C 20460

87-011

December 11, 1986

Honorable Lee M. Thomas
Administrator
U. S. Environmental Protection Agency
401 M Street, S. W.
Washington, D. C. 20460

Dear Mr. Thomas:

The Science Advisory Board's Water Quality Based Approach Research Review Subcommittee has completed its review of the Agency's Water Quality Based Approach research program and is pleased to forward its final report to you.

The Subcommittee met in public session on July 8-9, 1986 at EPA's Environmental Research Laboratory in Duluth, Minnesota. Prior to its meeting, the Subcommittee received a document prepared by the four EPA laboratories that carry out research in this particular program and entitled "Reference Material for Science Advisory Board Review of Water Quality Based Approach for the Control of Toxics - Freshwater."

The major issues addressed by the Subcommittee included the following:

- Use attainability: application of the ecoregion concept.
- Development of water quality criteria and advisories: data requirements and utility.
- Effluent toxicity: practicability of toxicity limits, chemical identification.
- Exposure: fluctuation, duration and frequency.
- Validation - Evaluations: national criteria, site specific criteria and effluent toxicity.
- Waste load allocation: level of sophistication required.
- Methods standardization and accuracy: when is a method ready for use?

One of the Subcommittee's major conclusions is that methods for deriving water quality criteria have undergone a steady evolution and extensive scientific review. These methods and the resulting criteria have wide acceptance by the scientific and regulatory communities. Many of the Subcommittee's recommendations are directed at further strengthening the water quality based approach, and integrating it with work related to other areas of toxic controls needing attention.

Thank you for the opportunity to present the Subcommittee's views on this important research program. We request that EPA officially respond to the scientific advice provided in this report.

Sincerely,

Kenneth Dickson, Chairman
Water Quality Based Approach Research
Review Subcommittee

Norton Nelson, Chairman
Executive Committee
Science Advisory Board

SAB-EC-87-011

# Review of EPA Water Quality Based Approach Research Program

by the Water Quality Based Approach

Research Review Subcommittee

of the

Science Advisory Board

December 11, 1986

## EPA NOTICE

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# I. INTRODUCTION

## A. Origins and Purpose of the Review

At the request of EPA's Office of Research and Development, the Science Advisory Board (SAB) has conducted a series of reviews of its ongoing research programs. The SAB reviews are conducted under the auspices of its Executive Committee which has formed specific subcommittees of qualified experts to address the scientific issues relevant to each program. The purpose of these reviews is to peer review of existing and planned scientific research, and to communicate to the Agency's research scientists, program office personnel and senior managers - including the Administrator, Deputy Administrator and Assistant Administrator for Research and Development - the progress, or lack thereof, made in meeting research needs pertinent to the development of regulations and policies.

The Executive Committee established the Water Quality Based Approach Research Review Subcommittee to conduct the review of EPA's water quality based approach for the control of toxicants in freshwater. The Subcommittee met in public session on July 8-9, 1986 at EPA's Environmental Research Laboratory in Duluth, Minnesota.

Prior to its meeting, the Subcommittee received a document entitled "Reference Material for Science Advisory Board Review of Water Quality Based Approach for the Control of Toxics - Freshwater," and prepared by the four EPA laboratories that carry out the research in this particular program. These include the Environmental Research

Laboratories in Athens, Corvallis, and Duluth and the Environmental Monitoring and Support Laboratory in Cincinnati. EPA staff also provided supplementary support documents.

These documents fulfilled two functions: 1) summarizing existing research and facilitating discussion of proposed research and the future needs of the research program; and 2) identifying seven issues for the Subcommittee's review. The issues presented included:

- Use attainability: application of the ecoregion concept.
- Development of water quality criteria and advisories: data requirements and utility.
- Effluent toxicity: practicability of toxicity limits, chemical identification.
- Exposure: fluctuation, duration and frequency.
- Validation - Evaluations: national criteria, site specific criteria and effluent toxicity.
- Waste load allocation: level of sophistication required
- Methods standardization and accuracy: when is a method ready for use?

The Subcommittee could also raise additional issues that it deemed appropriate.

B. Application of Research Program Results to Regulation Development

The primary purpose of the various research programs within the Office of Research and Development is to generate technical data and support for EPA regulatory and other activities carried out under its authorizing statutes. The primary clients for the water quality based approach research program include the Office of Water and the Office of Federal Activities. Program priorities are established by ORD

working through a decision making mechanism called research committees which are co-chaired by ORD and regulatory office representatives. Five such committees exist to plan all of EPA's research, and the work of this particular research program is planned by the Water Research Committee.

The major regulatory activities the water quality based research program is designed to support in current and future years include the following:

1. Single chemical numerical water quality criteria will continue to be the starting point in developing water quality based approach NPDES permit limits, and for evaluating treatment effectiveness under the technology based approach permits.

2. Approximately five additional water quality criteria documents per year will be issued over the next five years for the accelerated control of toxics in NPDES permits, land banning for RCRA and site investigation for Superfund.

3. Where data are lacking to develop a criteria, water quality advisories will be issued, about sixty per year for the next five years, to aid in screening NPDES permits, in controlling toxics in the water quality based approach.

4. A greater use of biomonitoring or whole effluent toxicity testing will be made in the next five years to determine if wastewater effluents are toxic and to establish NPDES toxicity permit limits in conjunction with single-chemical criteria in the water quality based approach.

5. Biomonitoring or whole effluent toxicity testing will be incorporated in toxicity identification, toxic reduction evaluation (TRE's) and pretreatment programs to control toxics in response to the Domestic Sewage Study and National Municipal Policy.

6. In the longer term, NPDES permits will need to address mixtures of pollutants from single discharges as well as those resulting from multiple discharges.

7. To aid in reviewing and issuing the next round of NPDES permits, a greater use will be made of user-friendly mathematical models, wasteload allocation software, and especially expert systems.

8. The need for and value of the control of diffuse and nonpoint source pollutants will be based on improvement in water quality using water quality criteria for known compounds and ambient toxicity testing for unknown compounds.

9. The ability to easily characterize wastewater effluents, chemically and/or biologically, will continue to be vital to the technological and water quality based approaches.

C. Historical Development of Water Quality Criteria

Since the passage of the 1972 Clean Water Act Amendments, the development of water quality criteria for the purpose of setting water quality standards has undergone a steady evolution resulting in more sophisticated approaches that have become increasingly equitable to both user and environment.

In 1971 the Environmental Protection Agency requested the National Academy of Sciences (NAS) to revise the 1968 Report of the National Technical Advisory Committee (NTAC) to the Secretary of Interior entitled "Water Quality Criteria." The guidelines used by the Academy were similar to those used by the NTAC, and were based upon the 1965 ammendments to the 1948 Water Quality Act. This Act authorized the states and the Federal government to set standards for interstate and coastal waters, considering the uses for such waters.

The NAS document produced (NAS, 1972) thoroughly utilized the information available at that time. An effort was made to define toxic levels at both the acute and chronic levels for several categories of water use including recreation and aesthetics, public water supplies, freshwater aquatic life and wildlife, saltwater aquatic life and wildlife, and agricultural and industrial uses. Though these criteria proved useful in guiding both state and Federal authorities, it was not until the Congress passed the 1972 amendments that the Environmental Protection Agency (EPA) was charged with the responsibility for establishing water quality criteria. The Agency responded with the publication in 1976 of "Quality Criteria for Water" (EPA 1976) which derived acute and chronic toxicant levels using conservative safety factors.

On May 18, 1978 and again on March 15, 1979 the Environmental Protection Agency published in the Federal Register guidelines for the formulation of water quality criteria. These guidelines improved over previously published

guidelines in that they considered the quality of the published data used in generating the criteria. Also considered were environmental differences, and other biological and physical factors which may have an effect on a criterion. Both acute and chronic levels were promulgated by using the methodology. In reviewing the guidelines, the Science Advisory Board commented on the magnitude of the variation encountered in the data leading to the formulation of a criterion level and suggested means to reduce this variation (EPA 1980).

In 1982, the Environmental Protection Agency prepared a draft Water Quality Standards Handbook (EPA 1984a) which introduced site specific considerations into the guidelines. EPA also included the concept of ecosystem protection which was directed toward structural elements of the ecosystem (protection of a specified number of families within any affected site).

These changes in the quidelines resulted significantly from research on an ever increasing data base by EPA scientists. The level of thinking (i.e., hypothesis generation and subsequent research activity) directed the evolution of criteria formulation.

At the present time, this hypothesis generation/testing process has moved the Agency into a water quality based criteria formulation methodology in which such previous imponderables as duration and frequency of exposure are considered with implications directed to control technology. Though this approach is subject to some criticism (EPA 1984b) it represents a major scientific advance in criteria formulation.

The future research agenda includes the area of whole effluent effects which revolves around the concept that organisms and ecosystems are not stressed by individual toxicants but by interactions of complex mixtures. Methodologies for the testing of whole effluent effects are being developed by EPA scientists and others.

The Subcommittee commends EPA, and particularly the water quality criteria research group of the Office of Research and Development and the Criteria and Standards Division within the Office of Water, for seeking ever increasingly relevant and refined methodologies for criteria formulation.

## II. CONCLUSIONS AND RECOMMENDATIONS

The Subcommittee reached the following conclusions and recommendations in its review of the research program:

- National Water Quality Criteria development is an important function of EPA's research laboratories. The Subcommittee recommends that the EPA continue its program of developing criteria and periodically reviewing and updating the criteria development guidelines.
- The methods for deriving water quality criteria have gone through a steady evolution and extensive reviews. These methods and the resulting criteria have wide acceptance by the scientific and regulatory communities.
- The whole effluent and ambient toxicity methods developed in support of the water quality based approach to toxics control appear to be major advances in water quality management. However, demonstration that the removal of effluent or other source(s) of toxicity to these surrogate species results in demonstrable positive ecosystem response should be an important goal for the Agency. Additionally, efforts to develop methods to assess toxicity persistence in receiving waters, sediment toxicity, or bioaccumulation, teratogenic, mutagenic, or carcinogenic potential should be expanded and be interfaced with single chemical fate and effects data.
- The recent addition of duration/frequency of exposure in the water quality criteria framework is to be commended.
- From a scientific perspective, spills, and resulting exceedences greatly above criteria concentrations, represent the greatest remaining weakness in the current intensity-

duration-frequency regulatory framework; thus, in spite of the statutory and practical limitation for regulating spills, the EPA research program should stress them.

- The Agency needs to evaluate the scientific basis and efficacy of the one-hour averaging period for the Criterion Maximum Concentration (CMC) and the four-day averaging period for the Criterion Continuous Concentration (CCC).
- The one-hour and four-day durations (averaging periods) for the CMC and CCC, respectively, present a practical problem for state agencies that must monitor effluents and receiving streams for compliance. The Subcommittee recommends that EPA develop appropriate guidance for states.
- Quantitative data on the relationships between frequency of exceedence of a criterion (CMC and CCC) and ecosystem damage and subsequent rates of recovery are lacking. The Agency needs to conduct research to establish a scientific base to establish the frequency component of national water quality criteria. The three-year frequency of excursions of the CMC and CCC now allowed by the EPA appear to be based on stresses caused by more catastrophic events than excursions of the CMC or CCC are likely to cause. The Subcommittee recommends a thorough review of the recovery literature and a reassessment of the frequency issue.
- The Subcommittee supports the use of field validation studies to investigate the reliability of currently recommended "short-chronic" effluent toxicity test procedures for predicting adverse ecological effects in receiving streams. In addition, research should be conducted to

develop standardized field methods for performing validation studies on water quality criteria for specific chemicals.

- The ecoregion methods of defining regional patterns in water chemistry and aquatic biota can be a valuable tool to help states define attainable goals in water quality and aquatic community improvement. The Subcommittee recommends the EPA continue to inform states of the ecoregion concept and assess ways in which the concept can be used in state regulatory programs.
- In the further development and application of the ecoregion/use-attainability program, the EPA should very carefully evaluate: 1) the scale of the ecoregion mapping effort; 2) alternatives for the biological measurements; 3) special applications for nonpoint source pollution; 4) special applications for retrospective analysis of water quality improvement/degradation; 5) user needs; and 6)user education.
- Pollution from nonpoint sources is a significant road block to attaining the national goal of fishable-swimmable waters in many parts of the country. The Subcommittee recommends that EPA research laboratories expand their efforts to define and characterize nonpoint source pollution leading to the more effective implementation of control measures.
- The Subcommittee does not support the development of Aquatic Life Advisories unless a minimum data base is established, a scientifically sound method is developed to derive the advisory concentration(s) and the method undergoes review by the scientific community. The Subcommittee

recommends that EPA consider an aquatic hazard assessment approach which relates environmental exposure to effects as an alternative to the present advisories approach.

- The selection of chemicals to develop criteria and advisories is an important activity. The Subcommittee recommends that the Agency develop selection criteria. It is suggested that hazard evaluation approaches be used which relate estimates of exposure to toxic effects. Utilization of environmental fate models and quantitative structure/activity relationships is recommended.
- The Agency needs to develop guidance materials including manuals and computer based expert systems to aid state agency and industrial personnel in exposure assessment and wasteload allocation.
- Research is needed to develop methods to assess the impacts of toxic chemicals on the structure and function of aquatic ecosystems.
- Research on the basic biology (e.g., physiology, pathology, nutrition and ecology) of test organisms is needed.
- The Agency should continue to develop and publish laboratory and field methods for assessing the effects of toxic chemicals.
- A critical need exists for a proactive technology transfer program to assist state agencies and industry in implementing the water quality based approach for toxics control.

- The Agency needs to coordinate this research program with efforts to develop sediment criteria for toxic chemicals.
- The Subcommittee recommends that EPA explore the inclusion of research on the potential environmental impacts of biotechnology as part of its endeavors in support of water quality based toxics control.
- The Subcommittee recommends that the Agency incorporate research on marine and estuarine ecosystems into its activities in support of this research program. A parallel effort to that underway for freshwater ecosystems is needed.
- EPA should develop a water quality monitoring program to assess the efficacy of the water quality based approach for toxics control to improve water quality limited aquatic systems.

## III. WHOLE EFFLUENT APPROACH

The transition from the technology based approach to the water quality based approach is fundamental to EPA's policy for the development of water quality based permit limits for toxic pollutants. The development of the Ceriodaphnia dubia and Pimephales promelas seven-day effluent and ambient toxicity tests represent significant milestones in the implementation of this policy. The Subcommittee commends EPA for the progress made in this area and encourages continued support as the methodologies are refined and expanded and experience is gained on interpretation of results.

The use of effluent and ambient toxicity tests to evalutate potential impacts is not without precedent. However, the use of the Ceriodaphnia dubia and Pimephales promelas tests as proposed in the Technical Support Document for Water Quality Based Toxics Control (EPA 1985) is a relatively recent development and changes in methodologies, interpretation, and direction should be anticipated. The implementation of these methods does not, nor was it intended, to address all aspects of toxics in the aquatic environment, nor have all the questions directly addressed by these methods been resolved. EPA should pay particular attention to such issues as bioaccumulation, persistence, sediments, multiple discharges, and teratogenic, mutagenic, and carcinogenic potential for initiation and/or promotion.

Bioaccumulation, or the potential for bioaccumulation of industrial chemical constituents from effluent mixtures, is not addressed by current effluent or ambient toxicity test

methodologies. Bioaccumulation, in the case of single discharges where manufacturing processes can be identified or where scans for priority pollutants might demonstrate presence of bioaccumulated chemicals, may be regulated by monitoring body burdens of resident organisms or through water quality criteria, where appropriate. However, EPA should direct some effort toward this process within the framework of complex effluents with unknown constituents. What is needed is a kind of generic n-octanol/water partition coefficient perhaps to be found in a HPLC approach.

Persistence is addressed, in part, by ambient toxicity measurements when tests are conducted on site. Few data appear to be available regarding correlations between on site ambient toxicity measures and samples shipped to a laboratory for evaluation. It remains to be seen if predicitive methods currently under development will contribute significantly to the current understanding of persistence.

If one defines as an objective of the water quality based approach the maintenance of structure and function of aquatic environments, the problem of regulating multiple discharges may need to be focused. In the case of multiple discharges, EPA should emphasize measurement of the system (ambient toxicity) and not the effluent. Only after the fractionation schemes currently under development become available for widespread use is it likely that both satisfactory regulatory and measurement tools will become available to fully evaluate

and manage multiple discharges.

The species currently used in effluent toxicity evaluations by EPA, and recommended in the Technical Support Document for Water Quality Based Toxics Control (EPA 1985), are water column organisms. Recognizing, as EPA does, that sediment is a significant component in the systems under evaluation, the Subcommittee recommends increased efforts in developing a short term sublethal benthic test methodology.

Toxicity to humans and the potential for teratogenic, mutagenic, and carcinogenic initiation and/or promotion to both humans and aquatic organisms are not addressed by these methods.

Ultimately the objective of the water quality based approach is related to managing, maintaining or improving water quality. To accomplish this objective the method employs collection of effluent and/or ambient toxicity data with surrogate species, assessment of potential impact, and management of toxicity by permitting an acceptable concentration or reducing or removing toxicity. Removal of toxicity from effluents beyond best available technology economically achievable will be a costly undertaking. Because the methods rely heavily on indirect measures of system impact it seems imperative that the EPA demonstrate that removal of the toxicity does in fact result in the maintenance or improvement of water quality. This is not an easy undertaking given the demonstrated difficulties in establishing significant correlations between system degradation and effluent toxicity. Nonetheless, the

Subcommittee believes this demonstration represents an important undertaking for EPA and one for which particular attention should be paid to ecologically significant improvements, rather than improvements which represent merely statistical significance.

## IV. NATIONAL WATER QUALITY CRITERIA GUIDELINES/ADVISORIES

### A. Background

EPA published revised National Water Quality Criteria Guidelines in 1985. In this section, the Subcommittee addresses some specific issues that comprise an integral part of the three-part water quality criteria by following the procedures advanced in the 1985 Guidelines document. The Subcommittee supports the continued development and updating of aquatic life criteria and encourages the Agency to continue research and development activities in this area. In addition, an assessment of the development of "Advisories" by the agency is discussed in the sections of this report which follow.

### B. Overview of 1985 Guidelines Approach to Establishing Water Quality Criteria

Briefly, acute toxicity data are collected on ecologically or commercially important organisms. Genus Mean Acute Values (GMAVs) are computed by taking the geometric mean of the LC50s or EC50s reported for members of the same genus. The GMAVs generally conform to a log triangular distribution, and estimation methods are applied to derive the Final Acute Value (FAV) as the fifth percentile of this distribution. Since the FAV is calculated from point toxicity estimates that cause an adverse effect in the test population (i.e., 50% mortality), the Criterion Maximum Concentration (CMC) is calculated as the FAV divided by two, and provides a "safe" level to 95% of the species tested. This concentration, on the average if not exceeded over a one hour period more than once every three years, is intended to

protect the receiving water from acutely toxic effects.

The assessment of chronic toxicity data for aquatic animals and plants, as well as information on bioconcentration of chemicals in aquatic organisms, yields a Final Chronic, Final Plant and Final Residue Value, respectively. The Final Residue Value is included to prevent aquatic organisms from obtaining body burdens that are believed to pose significant risk to human and wildlife consumers. The lowest of the above three values is designated as the Criterion Continuous Concentration (CCC), which provides an estimate of the highest four day average concentration that, if not violated with a frequency greater than once every three years, is advanced as being protective of aquatic organisms and their uses from being unacceptably affected by chronic exposure. In the development of a criterion, additional data regarding the effects on community structure and/or functional processes (e.g., respiration, productivity, nutrient cycling) or behavioral responses (e.g., preference and avoidance, swimming endurance, cough response) are also reviewed and professional judgment is used to evaluate the reasonableness of the two-number criteria, fresh and saltwater, derived via the formal procedure.

One of the most important features of stating criteria in accordance with the revised 1985 guidelines is that criteria are stated in terms of three properties: 1) concentration (intensity); 2) duration; and 3) frequency. Specifying criteria in such terms facilitates application of dynamic statistical models for determining water quality-

limited situations, rather than using the conservative and, hence, less cost-effective steady-state model based on 7Q10 flow or the worst-case scenario (Jaworski and Mount, 1985).

C. Intensity (Exposure Concentration)

"Intensity" is defined by EPA in the Technical Support Document (EPA, 1985a) as "how much of a pollutant (or pollutant parameter such as toxicity), expressed as a concentration, is allowable." The "Intensity" values for single chemicals or whole-effluent toxicity are specified in terms of the CMC for protection against acute effects and the CCC for protection against chronic effects. The methods for deriving these criteria values have gone through a steady evolution and extensive review, as discussed in the above sections. And although the resultant criteria (intensity) values have been a matter of disagreement for several individual chemicals (e.g., selenium) or because of a perception that national criteria are overly conservative, the criteria and their methods of derivation have been widely accepted by the scientific and regulatory communities. Use of the steadily improved criteria values in the NPDES permitting process has no doubt been responsible for much of the considerable improvement in surface water quality in the past decade. Moreover, the recent incorporation of a mechanism for reasonably incorporating duration and frequency of exposure in the regulatory framework (see Sections IV.D and IV.E below) will undoubtedly result in additional improvements in surface water quality. However, once the nation begins to achieve the water quality improvements

possible through the addition of duration/frequency concepts in the regulatory framework, a significant water quality problem likely will remain because "intensity of exposure" does not include consideration of "spills."

The 1985 National Guidelines specify that exceedences in magnitude of exposure greater than a factor of two over the CMC or CCC are not considered in formulating criteria. Because spills are not part of the normal operation of waste treatment facilities, high concentrations caused by spills and other accidents are not what is meant by "exceedence" of criterion concentrations in the Guidelines. The Technical Support Document (EPA, 1985a) recognizes the importance of spills, though, and points out that the allowable frequency of exceedence (3 years), which would allow ecosystem recovery, is not considered valid if spills (and relatively severe ecosystem damage) are prevalent: "If the biological community is under stress because of spills... the frequency [once every three years] should be decreased" (EPA, 1985a, footnote on page D-6).

Perhaps one of the most significant findings of EPA's (ERL-Duluth) recent work under the complex effluent toxicity testing program was the discovery that, in three out of eight field studies, spills of pollutants resulting in acute toxicity were documented. This seemingly high frequency of spills suggests that their effects may be as important as impacts caused by normal variations in effluent composition, concentration and dilution flow (EPA, 1985a, page D-4).

Unfortunately, spills are not regulated discharges under NPDES permit limits. From a purely scientific perspective, however, spills and resulting exceedences greatly above the CMC, no doubt represent the greatest remaining weakness in the consideration of "intensity of exposure" in the current intensity-duration-frequency regulatory framework.

In view of the apparently critical importance of spills in defining biological integrity, and because of the problem that this causes for the scientific basis of "intensity of exposure" in the current regulatory strategy, the EPA research program should more aggressively address spills. Even within the current statutory and practical limitations for regulating spills, a better scientific understanding of the frequency of spills in different types of water bodies, resulting magnitudes of excursion, and the extent of resultant ecosystem damage can, at least, help define the nature of the problem. If data show that spills are now a major contributor to significant water quality degradation, alterations in the Clean Water Act and EPA regulations might be necessary. A research program to consider the prevalence of spills, resultant effects on national water quality, and possible solutions might include the following:

1. Studies of spill intensity, frequency and duration in typical surface waters and for different industrial sectors. Such studies could use existing data from self-monitoring reports and fish kill records, as well as collection of new information using ambient toxicity tests and field studies.

2. Studies in the laboratory and field (model ecosystems?) on the relationships of levels of exceedence over the CMC (e.g., 2X, 20X, 200X CMC) causing ecosystem destruction for different classes of chemicals. These kinds of studies could be done in conjunction with the current research efforts on time requirements for ecosystem recovery.

3. Engineering studies on designs and operating practices to minimize occurrence or to effectively contain or dilute spills in different industrial sectors.

4. Studies of ecosystem parameters that are impacted by spills, for example the ratio of autochthanous and allochthanous activity, energy state of ecosystem (level of system eutrophy).

D. Duration (Averaging Periods)

As advanced in the 1985 Guidelines, EPA specifies a one hour averaging period for the Criterion Maximum Concentrations and a four day averaging period for the Criterion Continuous Concentration. The CMC portion of a National Water Quality Criterion represents the average concentration in over one hour which, if not exceeded more frequently than once every three years, will protect from acute toxicity 95% of the aquatic organisms in the receiving system. The CCC comprises the four-day average concentration which, if not exceeded more frequently than once every three years, will protect from chronic toxicity 95% of aquatic life in the recovery system 95% of the time.

Acute and chronic toxic effects are a function of both intensity (concentration) and duration (time). In developing the CMC, results of 48-hour to 96-hour LC50 or EC50 toxicity tests that have a constant exposure concentration are used. Many chemicals express their toxicity rapidly while some act more slowly. In establishing a one hour averaging period for the CMC, EPA has taken a conservative position that protects against fast acting chemicals. The effects on ecosystem integrity of an exceedance of the CMC for a duration (averaging period) in excess of one hour will depend on the magnitude of the excursion above the CMC and length of excursion. The effects will be chemical-specific depending on the rates and modes of action and, thus, the rates at which effects are expressed. Another factor influencing whether or not an effect is observed results from whether or not the exposure is constant or fluctuating. Field studies conducted by EPA and others have shown that concentrations of chemicals in receiving systems are usually continuously fluctuating and not constant (Mount et al., 1986). Thus, several factors influence the magnitude-duration interaction to cause an effect. Scientific data on the ecosystem effects of exceeding the one-hour averaging period of the CMC by different magnitudes (and, similarly, data on the ecosystem effects of exceeding the four-day averaging period of the CCC by different magnitudes) for different chemicals are not available to validate the degree of protection provided by these averaging periods.

The Subcommittee concludes that the Agency needs to conduct a literature review to ascertain what is known about the duration and mode of exposure (i.e., continuous versus fluctuating) for chemicals having different rates and modes of action. EPA should use the results of this literature review to evaluate the efficacy of the one-hour averaging period for the CMC and the four-day averaging period for the CCC. The results could also be used to identify research needs to develop the scientific knowledge necessary to relate averaging period to rates and modes of action. Rather than having the same averaging periods for the CMC and CCC for all chemicals, it should be possible to have different averaging modes of action. The use of a one-hour duration for the CMC and a four-day duration for the CCC poses practical problems for regulatory agencies that must monitor (or require the monitoring of) effluents and receiving streams for compliance. The Agency should examine the duration aspects of criteria from both the scientific perspective and the practicality of implementation.

E. Frequency

Both the CMC and the CCC in the 1985 Guidelines have an allowed excursion frequency of once every three years. From a scientific viewpoint, it is extremely important that the allowed frequency utilized in water quality criteria be derived from a strong scientific data base regarding the ability of aquatic ecosystems to withstand acute and chronic stress and still maintain their structural and functional

integrity. The Agency, in developing the Technical Support Document (TSD) for Water Quality Based Toxics Control, reviewed the available scientific literature and concluded that most unstressed biological communities would not be "sufficiently" affected if, on the average, one exceedance event occurred every three years. The TSD acknowledges that the frequency with which a criterion can be allowed to be exceeded depends on the structure and function of the aquatic community, on the spatial relationships to other non-affected areas, on the presence or absence of other stresses, on the size of the impacted area, on the type and size of the ecosystem, on the interval between exceedances, on the time of year of the exceedance and a host of other factors. Thus, the exceedance frequency could be site specific, just as the CMC and CCC can be site specific.

It is evident that quantitative data on the relative contributions of the above factors to the rates of ecosystem recovery are currently lacking and that a carefully developed research program is needed to establish a scientific base upon which to establish the frequency component of both national water quality criteria and the waste load allocation of the water quality based approach for toxics control.

From the discussions presented at the Duluth meeting, the Subcommittee believes that EPA is aware of the limited nature of scientific knowledge related to the frequency with which different ecosystems can be stressed and still maintain their integrity.

The initiation of a literature review to identify factors controlling the recovery of aquatic systems from disturbances (Niemi project) represents a start. The results of this effort should augment the information assembled in the Technical Support Document for Water Quality Based Toxics Control. EPA should use this study to assess the scientific knowledge regarding the recovery of ecosystems from stresses. It should also serve to identify research needs on the topic and to further focus EPA's efforts.

From both the Technical Support Document and the Subcommittee's experience, it is evident that most knowledge regarding rates of recovery stems from studies following major spills of chemicals (i.e., major stresses on ecosystems). Comparison of an exceedance of a CMC and/or a CCC in a National Water Quality Criterion to the stresses produced by a spill and its impact on the rate of recovery of ecosystems appears to be tenuous. EPA needs to experimentally determine the relationship between the degree of exceedance of the CMC and CCC, and structural and functional responses of ecosystems as well as the relationship between the frequency of exceedances and structural and functional responses of ecosystems, and rates of subsequent recovery. Scientific data do not appear to exist to judge the appropriateness of an allowed frequency of once in three years for exceedances of the CMC and CCC. EPA should use caution in applying the results of studies of recovery of ecosystems following spills of chemicals to establish the frequency for National Water Quality Criteria.

The ecosystem stress caused by an exceedance of the CMC or CCC more than once in three years is probably far less catastrophic than a spill of toxic chemicals in which the concentration of chemical may be exceedingly high (much greater than a factor of two above the CMC; see Section IV.C, above) and cause lethality to all or most organisms. In contrast, an exceedance of a CMC and/or CCC of 10-20% several times a year may not be measurable in terms of ecosystem impact due to the inability to assess structural and functional ecosystem responses with great accuracy. EPA needs to initiate research efforts to address these issues.

F. Aquatic Life Advisories

Overall, the Subcommittee reacts negatively to the development of water quality criteria advisories because it believes that the issuance of any number as guidance based upon a compilation of disparate data represents a step backwards to the pre-1978 approach, and completely ignores the technical progress made in establishing a method to derive water quality criteria and a state-of-the-art approach to environmental safety assessment.

The Subcommittee does not recommend the use of the advisory concept unless EPA: 1) establishes a minimum data base; 2) develops a scientifically sound method to derive the advisory concentration; and 3) provides a procedure for appropriate review by the scientific community combined with ample opportunity for public comment.

The Subcommittee is concerned that users of advisories would view any concentration values given therein as criteria which could be translated into standards. If data used to

develop advisories are insufficient, there might exist a great potential for misuse. The inability of EPA to issue aquatic life water quality criteria at the pace that some people would like must not be the driving force to inappropriate guidance that will result in scientifically unsupportable regulations at the state level. EPA, the states and the scientific community have made too much progress in the past decade to adopt a quick fix that will create as many or more problems as it is supposed to resolve.

The Subcommittee believes that, within the current Toxic Substances Control Act's premanufacturing notification (PMN) process and the NPDES regulatory programs, there exists a scientifically sound alternative to derive "advisory concentrations." The conceptual basis of the alternate approach lies within the framework of the aquatic hazard assessment process for which there is adequate documentation (Cairns et al., 1978; Dickson et al., 1979; Bergman et al., 1986; Kimerle, 1986 Gilford, 1985; EPA, 1985a). The concepts which are applicable are as follows:

- The hazard assessment process utilizes some estimate of exposure and the toxicologically safe concentration to derive the margin of safety. The decision or assessment is always based on the margin of safety, the difference between the exposure and effect concentrations. The current EPA water quality approach requires that a margin of safety of at least one be maintained to protect aquatic life.

- Less than the complete multispecies acute and chronic data base now required for deriving water quality criteria can be successfully used by employing the concept of uncertainty (Gilford, 1985; EPA, 1985a). Uncertainty factors of one to one thousand are used, depending on the extent of the toxicological data base, to arrive at an estimate of the concentration that will be safe for aquatic life.
- Data are collected in tiers with an initial minimum acute toxicity and exposure data base. The trigger for requiring additional data beyond the minimum is the margin of safety.

Some members of the Subcommittee were supportive of the development of Advisories for the practical reason that advisories can serve a very useful purpose for state agencies who need information regarding the potential hazards of toxic chemicals. A real need exists in state regulatory agencies for "guidance" on chemicals lacking enough data to establish criteria.

## G. Selection of Chemicals to Develop Criteria and Advisories

The Subcommittee believes that the overall water quality approach to manage the discharge of toxic chemicals in toxic amounts is technically and strategically sound. However, since the development of the comprehensive method to derive chemical-specific water quality criteria in 1980 and the revisions up to 1985, EPA has completed and issued very few

two-number aquatic life water criteria documents from the original priority pollutant list of 129 chemicals. An issue that needs to be addressed, in light of the fact of limited resources, is how to identify chemicals needing the development of full aquatic life water quality criteria. Although the list of 129 chemicals has some chemicals that are of national importance and deserve a national water quality criterion, many of the chemicals on the somewhat arbitrarily chosen list of 129 probably should receive a lower priority than many chemicals not currently on the list.

The Subcommittee concludes that it would be worthwhile to develop a procedure to identify and set priorities for chemicals that need a water quality criterion. Further, it suggests that the basis of that procedure might utilize some of the newer concepts of hazard evaluation and approaches to estimate exposure and toxic effects. Chemicals that demonstrate a large margin of safety between an estimated or measured exposure and an estimated or measured toxicity data base could receive a lower priority for consuming limited resources than a chemical with an obviously smaller margin of safety. Many new techniques are now available to use physical/chemical property data to "model" exposure concentrations in air, water and soils. Models are also available to predict transformation processes like hydrolysis, photolysis, adsorption, partitioning, and degradation which alter the concentrations of chemicals in

the various environmental compartments. A direct approach to determine if exposure is of national concern is to measure exposure concentrations in water, sediments, and fish. To estimate toxicity the use of quantitative structure/activity relationships and existing published acute toxicity data could provide a valuable starting point. Actual acute toxicity and short term "chronic" tests could be performed with a minimum number of species.

The EPA staff in both ORD and the Office of Water should examine the TSCA-PMN process and NPDES Technical Support Documents for guidance on how to deal with the uncertainty of less than complete data bases and to make expeditious decisions.

As factors for selecting chemicals for which criteria or advisories are to be developed, the Agency should include chemicals commonly encountered by state agencies in receiving waters, landfill leachates, petroleum product spills and hazardous waste sites.

## V. VALIDATION RESEARCH

One type of validation study presented to the Subcommittee involved investigations of the use of effluent and ambient stream toxicity tests for predicting effects on aquatic systems that receive toxic discharges. A principal objective of these investigations, conducted at eight field sites, was to evaluate the relationship between toxicity results observed in Ceriodaphnia reproduction tests and fathead minnow larval growth tests with ecological survey data collected in the receiving waters. While the Subcommittee was cognizant of the labor-intensive efforts (costs) required by such investigations, it strongly supports the appropriateness of this approach for validating the currently recommended effluent toxicity test procedures for predicting adverse ecological effects. It recognizes that the inherent properties and complexities of natural (ecological) systems make it difficult to obtain definitive correlations between toxicity test data and biological effects that may ultimately result in the aquatic environment. For this reason, the Subcommittee suggests that EPA continue these or similar types of validation studies, but that other ecological parameters in addition to "species richness" be used and evaluated in the validation process.

Another area of validation effort addressed by the Subcommittee involved the field studies performed at the Monticello Ecological Research Station (MERS) to evaluate the utility of water quality criteria established for specific chemicals (i.e., PCP, ammonia, chlorine). The Subcommittee

believes that it is desirable for EPA to continue this type of research, for it appears to be a logical approach for validating numerical values derived for national criteria. However, due to high variability in the other ecosystem parameters monitored during the validation experiments, data showing the degree of protection to other structural and/or functional components are limited. As with the validation investigations described for complex effluents, it should be noted that environmental variables encountered in site-specific studies confound the determination of precise correlations between field data and laboratory test results. Therefore, an area of future research worthy of consideration involves the development of standardized field methods for performing validation studies. Research should also be conducted using the MERS to further evaluate the degree of protection afforded by national water quality criteria to ecosystem components other than fish.

## VI. USE ATTAINABILITY AND ECOREGIONS

The fact that water quality characteristics and aquatic communities vary regionally with climate, surface geology, soils, vegetation and land use patterns is not a new concept. The ecoregion mapping program developed by the staff at the Environmental Research Laboratory - Corvallis presents a consistent and defensible representation of these patterns nationwide. Tests of ecoregion delineations in at least two states, Arkansas and Ohio, have demonstrated similar water chemistry and stream communities within an ecoregion and differences in these characteristics between ecoregions.

Since water quality varies naturally from place to place, it is not only appropriate but imperative that Federal and State regulatory agencies consider this fact in their efforts to achieve the national goal of fishable-swimmable water "wherever attainable." When setting water quality standards and effluent limitations, states must be aware of the local water quality background and the aquatic community being protected. The ecoregion approach is a tool that can help states and EPA regional offices define regional goals for attainable water quality and aquatic biota. This tool is especially useful in defining the water quality and aquatic community attainable in a given region. Thus, regulatory officials and scientists can establish reasonable goals for expected improvements following pollution abatement efforts. Ecoregions will not, however, replace the need for wasteload allocations and site-specific toxicity studies necessary to establish effluent limitations for individual dischargers, although they will facilitate modeling for wasteload alloca-

tion within each region.

In Minnesota, as one example, the ecoregion approach is being used for two primary purposes as follows: 1) to assist the Minnesota Pollution Control Agency (MPCA) focus and prioritize its nonpoint source pollution control programs; and 2) to aid in the analysis of statewide water quality data. In the first instance, the MPCA has assessed characteristics within Minnesota's eight ecoregions that are pertinent to the evaluation of nonpoint sources and to the application of best management practices for nonpoint source pollution control. Many of Minnesota's lakes are impacted by nonpoint source pollution. To help address this problem, the MPCA is working on a total phosphorus water quality standard for lakes using the ecoregion concept. Assessing lakes by ecoregion helps define the trophic status that can be achieved in a given lake. The MPCA has identified regional patterns in several lake characteristics that can affect trophic status such as morphometry and stratification patterns, as well as nutrient concentrations. Under the second example, the MPCA has analyzed its ambient water quality data by ecoregions for the biennial report of water quality to Congress (305b Report).

The Subcommittee recognizes the absolute necessity for improved strategies of use attainability analyses as well as the potential value of the ecoregion concept as a regional tool to help agencies define patterns in water chemistry and

aquatic biota, which are in turn helpful in defining use attainability.

The Subcommittee has several concerns about both the development and the application of the ecoregion mapping concept and use-attainability analysis method. In the further development and application of the ecoregion/use-attainability framework, the Agency should very carefully evaluate: 1) the scale of the ecoregion mapping efforts; 2) alternatives for the biological measurements; 3) special applications for nonpoint source pollution; 4) special applications for retrospective analysis of water quality improvement/degradation; 5) user needs; and 6) user education.

1) Scale. The most reasonably attainable and usable scale of the ecoregion mapping effort should be carefully evaluated. The tendency for these kinds of efforts is to continue to develop finer and finer scales in the analysis and mapping. This tendency is driven by the correct perception that a course (national, regional) scale is not useful for local application of ecoregion maps to use-attainability questions. But this fact must be balanced with the actual need (or lack of need) for fine scale maps at all localities, as well as the achievability of such maps given the data limitations that are likely to exist. One option for the Agency to consider would be the completion of national and regional maps for analyses at those levels, accompanied by a guidance document and training programs to assist state agencies in data collection and mapping at finer

scales for surface waters where it is appropriate and useful for use-attainability analyses. This local level analysis and ecoregion mapping approach may be very useful for important surface waters to set site-specific water quality standards, to set effluent limitations for specific discharges, to establish nonpoint source controls, and to evaluate progress in attaining water quality improvements.

2) Biological Measurement Alternatives. The biotic index approach, based on fish community analysis, offers considerable promise for ecoregion mapping and use attainability analysis. However, alternative approaches should continue to be considered by the Agency and used, if and where appropriate. Two examples of alternative approaches include fish Habitat Evaluation Procedures (HEP) and ecosystem function measures. The HEP approach has been developed extensively by the U.S. Fish and Wildlife Service and could be very useful for use-attainability analyses and, thus, local scale ecoregion (habitat) mapping (see Dickson and Rodgers, 1986). Ecosystem function measurements (e.g., primary production or production/respiration) may be very useful for analysis and management of many nutrient-related nonpoint source pollution problems. In a previous manual on water body surveys and assessments, EPA (1984b) reviewed a number of biological measurement alternatives for use-attainability analyses. The Subcommittee recommends continuation of this practice rather than selecting any single method for biological assessment of surface waters.

3) Nonpoint Source Applications. The Subcommittee agrees that the ecoregion mapping approach would be

especially useful in nonpoint source evaluations (as presented in the Minnesota example, above). Since this type of application was not discussed extensively during the review, the Subcommittee can only recommend that the Agency carefully consider whether the ecoregion mapping effort (including preparation of guidance to regional and state agencies) accounts for the variables that would be most important for nonpoint source problems (e.g., soil erodability, prevalent agricultural crops, primary production).

4) Retrospective Analysis Applications. The Subcommittee suggests that the ecoregion mapping/use attainability framework should be applied to the assessment of national and regional progress in achieving surface water quality improvements. Although states are required to submit biennial National Water Quality Inventory reports (305b reports) that are reviewed and summarized by EPA, too little effort appears to be expended by EPA in compiling these kinds of "progress reports." Such progress reports should be very useful for EPA in allocating resources for further improvements that are needed and achievable. The ecoregion concept could be useful for subdividing this problem if the ecoregion mapping exercises were approached with such an application in mind (also see Section IX. F).

5) User Needs. As in any research program where the products of national-scope research efforts are to be applied to local-scale problems, it is imperative that the

researchers maintain frequent contact with regional and local users to be sure that the intended research product will meet local needs. Thus, the Subcommittee encourages the research team at ERL-Corvallis to continue solicitation of critical imput from regulators and regulated parties in the field through presentations at national, regional and local meetings and workshops. During these exchanges, the research team should invite critical input on alternatives (e.g., biotic index, HEP, ecosystem structure and function, ambient toxicity assessment) as well as special needs associated with various applications of the ecoregion mapping/use-attainability framework (e.g., point source, nonpoint source, ambient toxicity assessment). The Agency should also continue applications/demonstrations, such as those in Ohio and Arkansas, prior to settling on the final form for the ecoregion mapping/use-attainability approach.

6) User Education. Once fully developed, a carefully prepared, complete guidance document should be drafted (e.g., EPA, 1984a) and subjected to scientific and user review. The final draft of this document should then be used as the basis for regional workshops on the application of ecoregion mapping/use-attainability in regional and state programs. The successful effort by EPA on the preparation and dissemination of the Technical Support Document for Water Quality Based Toxics Control (EPA, 1985a) should provide an excellent example for this program.

## VII. WASTELOAD ALLOCATION

Exposure assessment involves predictions of how much, how long and how frequently a receiving system is subject to concentrations of chemicals and/or effluents exceeding water quality criteria. The spatial and temporal extent of aquatic life exposure to toxicants will vary depending on variations in the assimilative capacity of the receiving water and variations in effluent composition and quantity. Regulatory agencies utilize wasteload allocation (WLA) models in the water quality based approach for toxics control to predict exposures and to calculate the effluent quality required to meet the criteria and protect the beneficial uses of the receiving water.

The major responsibility within EPA for conducting exposure assessment research and developing WLA models resides with the Environmental Research Laboratory at Athens. This laboratory currently has six major research activities to support wasteload allocation and permitting from a single chemical modeling perspective. They include:

- Environmental and chemistry processes characterization and research
- Biodegradation and bioaccumulation processes characterization
- Expert systems to predict chemical/physical reactivity and transport properties
- Expert systems for environmental management
- Load allocation models development and evaluation
- Technology transfer and user assistance

Based on the materials supplied to the Subcommittee and

on the presentations at Duluth, it appears that the activities at Athens effectively address the major research and development needs related to exposure assessment and wasteload allocations. The development of expert systems to assist users (i.e., permit writers and environmental decision makers) is an important area which the Subcommittee recommends for a high priority in allocation of resources. For the Agency's water quality based toxic controls program to succeed, permit writers must be able to effectively use environmental fate and load allocation models. These models are complex and require significant understanding and experience on the part of the user. Expert systems provide an effective means of transferring the knowledge and skills of environmental fate scientists and modelers to the user.

## VIII. METHODS STANDARDIZATION

### A. Field Methods

One of the more difficult endpoints to define is the effect of a toxicant on ecosystems. Though difficult to obtain, ecological scientists have tested several measures that offer some hope of assessing ecosystem effects. Research is needed, however, to quantify these effects and identify additional measures.

Ecosystem attributes can be categorized into three groups: 1) state variables which encompass such structural attributes as standing biomass, species richness, species diversity, species importance and trophic levels; 2) process variables which include such attributes as rates of uptake from one trophic level to another, and rates of photosynthesis, respiration, and metabolism; and 3) control variables which control the rates at which processes proceed. A keystone species controls the structure of the ecosystem and in so doing controls the processes.

The Subcommittee encourages the Agency to continue to develop field methods to assess the impacts of toxic chemicals on aquatic life.

The reemphasis on measuring and alleviating impacts to biological systems further demonstrates the need to develop methods to characterize and measure impacts. It also focuses, as has EPA's acid deposition program, attention on the need for long-term monitoring of ecosystems. The value of documented historical data bases cannot be overemphasized.

B. Basic Biology of Test Organsisms

The role of methods standardization, quality assurance, and technology transfer in the water quality based approach to toxics control should not be underestimated. The development of the Ceriodaphnia dubia seven day toxicity test should have reinforced the necessity to develop programs to produce information on the basic biology (e.g., physiology, pathology, nutrition and ecology) of test organisms, the methods to culture and test the organisms, and to transfer the methodology to potential users. It is also important to continue to seek new species, or modify methods for existing species, as a means to add to the collection of organisms satisfactory for use in evaluations of aquatic ecosystems.

C. Publication of Standardized Methods

The research and development activities at the Environmental Monitoring Support Laboratory at Cincinnati have provided valuable data germane to the water quality program. One important contribution has been the development and publication of standardized methodologies for effluent biomonitoring. Activities at EMSL Cincinnati that warrent continued support include additional evaluation and standardization of short-term effluent toxicity tests with other saltwater and freshwater organisms; the development of new and rapid toxicity test methods; the establishment of additional reference toxicants for determining toxicity test precision; and the completion of new toxicity testing method manuals. Because of EPA's increased emphasis on the

environmental and regulatory importance of sediment-associated toxicants, the development and standardization of test methods for evaluating sludges, leachates, sediments, and hazardous wastes appear to be especially relevant.

## IX. AREAS RELATED TO THE WATER QUALITY BASED APPROACH TO TOXIC CONTROLS NEEDING ATTENTION

### A. Nonpoint Sources

In many parts of the country, pollution from nonpoint sources is a more serious problem than pollution from point sources. Programs to monitor, assess, and control point source pollution are well established, but many states are only beginning to develop nonpoint source pollution control strategies. Most of the research programs at the EPA research laboratories have been directed toward the control of point source related problems.

The Subcommittee recognizes the importance of dealing with the nonpoint source pollution problem if the nation is to achieve the national goal of fishable-swimmable water wherever attainable. The Subcommittee also is aware that, in may respects, the control of nonpoint source pollution represents a greater challenge than controlling point sources. The Subcommittee recommends that EPA expand its research effort in nonpoint source pollution and has identified the following issues as needing research priority:

- What are the impacts to aquatic communities from the runoff of pesticides, herbicides, and other toxics from nonpoint sources, considering the intensity, duration, and frequency of exposure?
- What are the loading dynamics of nonpoint source toxics to streams in a given watershed?

- What water quality characteristics are the best for monitoring nonpoint source pollution over the long-term?
- What are the appropriate water quality criteria for toxics and conventional pollutants for assessing nonpoint source pollution?
- Will the implementation of best management practices in a watershed to protect surface waters from nonpoint sources have a negative impact on area ground water?

B. Technology Transfer

The Subcommittee realizes that the water quality based approach requires a higher degree of technical expertise than previous efforts. Therefore, a need exists for the EPA to inform, educate and provide technical assistance to state regulators and industries to incorporate this approach into their pollution control programs. Specific assistance is needed in: 1) calculating water quality criteria following the EPA prescribed method; 2) incorporating the two number criteria into usable programs; 3) developing guidance on how to use the water quality advisory concept; 4) determining use-attainability; 5) calculating wasteload allocations; 6) establishing routine use of computer models in wasteload allocations; 7) identifying sources of toxicity; and 8) implementing of the Technical Support Document for Water Quality Based Toxics Control.

Successful attainment of the national goals contained in the Clean Water Act depend greatly upon implementing this new technology. Therefore, a commitment needs to be made to

transfer this technology. Because this activity is so important, EPA should consider constituting a dedicated team of technology transfer experts to prepare and present the approach in a comprehensive program to the user community. The format could take the form of guidance manuals, workshops, and seminars. Representatives from industry and state regulatory agencies should participate. The program goal should be the education of all parties concerned, especially individuals at the state level who would not ordinarily be given the opportunity to participate because of financial constraints.

C. Sediments

Based on a review of materials supplied to the Subcommittee and the presentations at the Duluth meeting, it is evident that EPA needs to direct more attention toward coordinating the water quality based approach for toxics control with efforts to develop sediment criteria for chemicals. Water and sediments in aquatic ecosystems interact via abiotic and biotic mechanisms. While often viewed as separate environmental compartments from an environmental fate and modeling perspective, it is well documented that the concentration of chemicals in water affects the concentration of chemicals in the sediments. The reverse is also true.

The degree of interaction depends on the chemical, water quality and physical/chemical characteristics of the sediments. Since the objective of the water quality based approach is to establish discharge limits and/or determine

allowable instream contaminant concentrations, it is essential to incorporate as part of the approach an assessment of the potential effects of an effluent on sediment quality and associated benthic organisms. The present efforts are totally directed to assessing exposure and effects in water. An assumption is made that protection of water column associated organisms will protect benthic organisms. The scientific basis for this assumption is not well developed.

The Agency needs to better coordinate and integrate its efforts between those staff developing sediment criteria for chemicals and the scientists at the environmental research laboratories that participated in the development of water quality criteria. Finally, EPA should consider factoring into the water quality based approach sediment interactions with effluents, and the role of sediments in influencing the fate and effects of chemicals.

If EPA does not factor sediments into the water quality based approach, it faces a real danger of misjudging an effluent as having no effect on the aquatic ecosystem based on water column focused assessment methods. It could subsequently discover that, because of the nature of the chemical constituents and the nature of the sediments in the receiving system, toxicants build up to harmful levels that adversely impact benthic organisms and organisms associated with the water sediment interface. The Subcommittee recommends that EPA explore this issue more seriously.

D. Biotechnology

The Subcommittee notes that the program contains nothing related to the important issue of biotechnology and its environmental impact. With the excellent water quality expertise available at the Duluth laboratory it would be prudent for EPA to have some of its staff involved in biotechnology environmental impact analyses. The Subcommittee recommends that EPA consider what role the Duluth laboratory personnel could play in this important national issue. Likewise, scientists at the Gulf Breeze ERL should be involved in the water quality based approach research activities.

E. Saltwater

During the Subcommittee's review, it was very clear that the Agency has not incorporated marine and estuarine ecosystems into its research and development efforts. The reasons for this omission are not clear. However, from a conceptual perspective the Subcommittee sees no reason why the water quality based approach should not be applied to marine and estuarine ecosystems. It is apparent from the Sixth Draft of Strategic Five Year Plan for Freshwater Ecological Processes and Effects Research that the Athens, Corvallis and Duluth laboratories have effectively incorporated research and development activities related to the water quality based approach into their future plans. The Subcommittee commends this effort, but it is essential to coordinate research efforts on the water quality based approach with marine and estuarine ecosystems. Methods for

rapidly assessing the fate and effects of effluents discharged into saltwater environments applicable to the water quality based approach, and models to estimate exposures and wasteload allocations, need to be developed along with freshwater approaches.

F. Monitoring

It is important to know that any effort once applied is effective. The attempts to do this in the water quality criteria area has been at best superficial. The President's Council on Environmental Quality has traditionally produced an annual state of the environment message. During those administrations when the Council carried a higher priority, this environmental message was designed to give a general impression of environmental quality and did not provide specific analysis to the point where one could gauge the degree of impact of a specific regulatory action. The Environmental Protection Agency was also charged in the 1972 Clean Water Act Amendments to produce a biennial National Water Quality Inventory. This effort relies heavily on the states to provide the information which is often incomplete.

EPA should test its strategies in water quality criteria formulation with a monitoring program based on a set of randomly selected streams in the United States with a view for following guideline and criteria formulation application and their effects on water quality.

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