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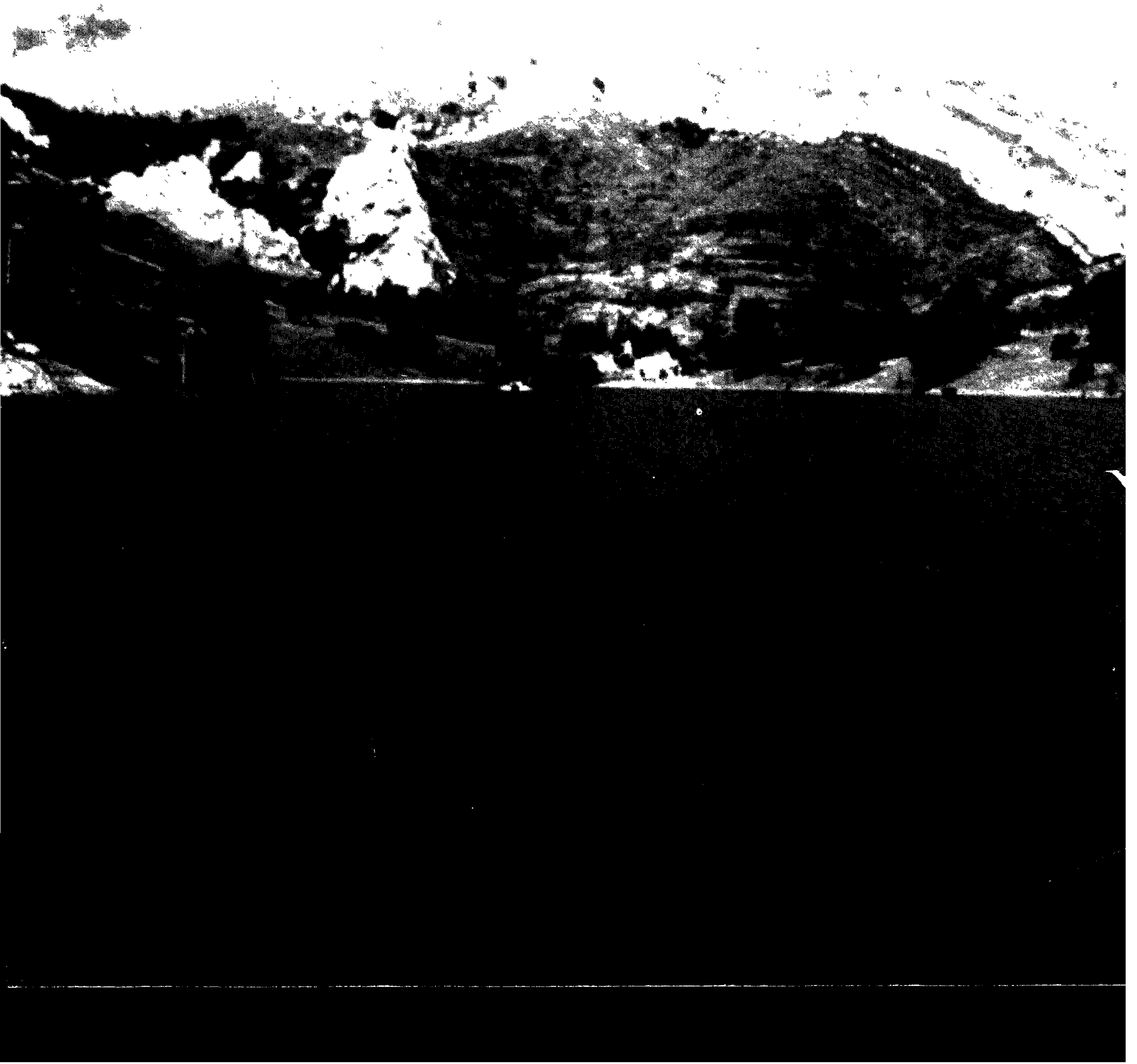
EPA

WATER QUALITY STANDARDS FOR THE 21ST CENTURY

Proceedings of a conference



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

JUN 1 1991

OFFICE OF
WATER

Dear Colleague:

Enclosed is a copy of the Proceedings of the 2nd National Water Quality Standards Conference held December 10 - 12, 1991, in Arlington, Virginia. We very much appreciate your attendance and participation in the spirited discussions.

The 3rd National Water Quality Standards Meeting will be held during September, 1992, in Las Vegas, Nevada. I would like your assistance in making the 1992 Water Quality Standards Meeting as successful as the first two meetings by taking a few moments to give us your views on the topics that should be covered and on the format of the meeting.

In the first meeting, we asked that you help us define what the breadth, scope and priorities of the evolving water quality standards program should be as we proceed into the 21st Century. Your suggestions included water quality standards for wetlands and greater emphasis on sediment and biological criteria. We adjusted the Agency's priorities for the water quality criteria and standards programs to reflect your suggestions.

The Agency's budget for sediment criteria, biological criteria and wildlife criteria has more than doubled over the last three years. In addition, EPA's operating guidance to States for the 1991 - 1993 water quality standards triennium includes State adoption of wetland and estuary/near coastal water quality standards and State adoption of narrative biological criteria.

The second national water quality standards meeting had a narrower focus. We sought your ideas on how best we can all contribute to implementing the water quality standards program priorities. The most prevalent suggestion was publication of implementation guidance that focuses on practical solutions.

However, there is no practical way for us to respond positively to all of the suggestions offered at the conference nor as quickly on the principal suggestions as we would like. We have initiated specific actions in response to suggestions from the second conference. In April, 1991, the Agency published the <u>Technical Support Document for Water Quality-based Control</u>. Revisions to the document reflect needs identified at the conference for certain kinds of guidance, such as guidance on mixing zones. We expect to have more definitive guidance available this fall on narrative biological criteria. Through the efforts of the States and Regions involved in the Great Lakes Initiative, much work is underway on developing implementation guidance in several areas, including application of the antidegradation policy and use of economic analyses in the water quality standards program. A policy statement on metals is nearly completed and ready to be issued. The discussions on the concept of national standards has been of assistance to the Agency as we begin work on the reauthorization of the Clean Water Act. In addition, as some of you may be aware, the Agency is reviewing the potency of dioxin. This review may result in a change in the dioxin criterion. Finally, the quarterly Criteria and Standards Newsletter is now devoted to topics of special interest, as suggested at the conference. Since the meeting in December, 1991 we have published a Newsletter on biological criteria and one on wetland water quality standards in which we identified the different approaches States are taking.

The format for the first two conferences included several featured speakers, panels on various topics, and an opportunity for questions from the audience. Your evaluations of the second conference included numerous suggestions for improvements based on this format. Do you have any suggestions for a basic format change or should we continue with the format of the first two conferences?

I hope that you will take the time to suggest improvements that we could make to ensure the success of the 3rd National Water Quality Standards meetings.

Sincerely,

William R Diamond

William R. Diamond, Director
Standards and Applied Sciences Division
Office of Science and Technology

Proceedings

Water Quality Standards for the 21st Century

December 10-12, 1990 • Arlington, Virginia

Sponsored by

Office of Water
U.S. Environmental Protection Agency

May 1991

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Purpose and Objectives of the Conference

Martha G. Prothro
Director, Office of Water Regulations and Standards
U.S. Environmental Protection Agency
Washington, D.C.

Welcome to Washington! You are a large and varied audience, and we eagerly look forward to hearing what you have to say about the water quality standards program. We all recognize that this is the keystone of the water quality-based control program and, in many ways, the key to implementing a watershed protection program that focuses on ambient and ecological protection rather than simple control of traditional sources of pollution.

In our last national meeting held in Dallas in March 1989, a variety of topics was discussed. From that meeting and follow-up discussions with various groups in and out of EPA, we decided on the national program priorities for fiscal years 1991 to 1993.

For the past three years our top priority has been State adoption of numeric criteria for toxic pollutants. While this remains a priority, other elements have been added. In the triennial–fiscal years 1991 to 1993–the States will be expected to adopt:

- Saltwater criteria for protection of aquatic life and human health,
- Narrative biological criteria,
- Provisions to ensure that standards apply to wetlands (just as standards apply to any other waterbody),
- Additional criteria for toxic pollutants as needed,
- Standards applicable to coastal and estuarine waters, and
- Antidegradation policies and implementation procedures.

At this year's conference, we want to discuss the problems and issues confronting EPA, the States, and others affected by standards in meeting these program priorities. We also want to identify what additional supporting guidance and policies are needed from EPA to support the States in meeting these objectives and to hear from environmental groups and industry as to how they will participate in State efforts on these tasks.

We believe you can help us identify the scientific, technical, legal, policy, and resource needs and impediments to achieving national program objectives. Every one of our current objectives has already been accomplished by at least some States, so we think our goals are realistic and appropriate. But we want to hear from you.

We hope this conference will serve as a national forum for States, Indian tribes, and environmental and industry groups to exchange ideas on ways and means to maintain and improve the standards program as a solid foundation for implementing water quality-based controls.

Water quality standards and the supporting water quality criteria are constantly changing. There will probably never be a time when we have all the information or all the resources we may need. Too often this becomes an excuse for lack of action despite the fact that there is sufficient knowledge and a need to act. We hope not only to identify problems or additional research needs that could be barriers to future program implementation but also to identify what we can do now and in the next few years, based on existing knowledge, law, and information.

If our experience from the 1989 meeting in Dallas is any guide, you will probably give us many more suggestions for program changes, research, and guidance than EPA and the States can reasonably deliver. Therefore, I ask that, as ideas develop during the various discussion sessions, we all try to think in terms of "doability" and rank priorities on the basis of managing the highest ecological and public health risks.

Subjects that we will be discussing at this conference include:

- Derivation and application of sediment criteria,
- Inclusion of wetlands and coastal area in State standards,
- Geographical targeting of programs, as illustrated by the experience gained to date on the Great Lakes Program Initiative, and
- A possibly stronger focus on the control of ammonia and chlorine.

We also will have an opportunity to discuss the upcoming Clean Water Act reauthorization with Congressional staff.

These are the near-term program objectives. We expect that discussions on some of the newer areas of consideration and the Clean Water Act reauthorization will begin to set an agenda for the national program beyond 1993.

As for potential new areas for standards, we can consider wildlife and numeric biological criteria and geographically targeting our programs on critical watersheds. We expect to focus more on nontraditional areas such as nonpoint sources, combined sewer overflows, and stormwater. Other areas where standards will either influence decisions or be influenced by them include fish contamination advisories, hydrologic modifications, 401 certifications, reductions of ecological and human health risks, and, most important, pollution prevention. This is a wide variety of possible issues for the standards program. We need your views on which areas are the most needed and the most promising in terms of environmental protection and which have the greatest need for additional research.

Our panelists represent a wide variety of interests and viewpoints. Each session is constructed to allow adequate time for audience participation. I encourage you to share your thoughts and ideas throughout the conference.

Welcome to all of you!

Keynote Address

LaJuana S. Wilcher
Assistant Administrator for Water
U. S. Environmental Protection Agency
Washington, D.C.

(As presented by Martha Prothro due to illness of Ms. Wilcher)

Welcome to our Nation's capital! I am delighted to join you for the Second Annual National Water Quality Standards Conference and the 25th anniversary of the water quality standards program. You are our partners. Without you, we could not have achieved the progress that has been made in improving our Nation's water quality.

Each of you has played a role in this program. Scientists have developed new methodologies and data to enable us to understand and predict the effects on human health and the environment—even very low amounts of toxics and other pollutants. The Federal actors have given us new regulations, policies, and guidance and have provided much needed technical assistance. States have been on the frontline, working with local interests to implement and generally ensure program operation. Environmental organizations have served as the conscience for the Nation, helping to foster a broad national commitment to protect water resources. And many others — lawyers, citizens, students — have, in their own ways, contributed to our success. Meetings such as this reaffirm our commitment to improving the water quality standards program. Your commitment is well worth the effort because here, on the "water planet," every living thing depends on it.

As William Blake said in "The Book of Thel," "...everything that lives, / Lives not alone, nor for itself." We humans don't live in isolation. We are integrally related to our rivers, lakes, streams, wetlands, and estuaries. Water covers two-thirds of the earth's surface. Essential to all forms of life, it plays the critical role in the functions and processes of the earth's ecosystems. Water is the single most common element uniting ecosystems: it links forest ecosystems in interior mountain ranges with the estuaries and bays along coasts. It transports food, nutrients, and other biologically important organisms and materials. It removes waste, cools, and maintains the climate conditions necessary to sustain life. Clean water is essential to almost every industry in this country and provides a multiplicity of recreational activities to our Nation. It is our lifeblood.

In 1854, Indian Chief Seattle said, "This shining water that moves in the streams and rivers is not just water but the blood of our ancestors. The rivers are our brothers, they quench our thirst. The rivers carry our canoes and feed our children. And you must henceforth give the rivers the kindness you would give to any brother."

But we have not always treated our water so kindly. In the past, we have taken water for granted. We used our rivers as open sewers and open garbage pits—as recipients of trash, waste oil, and even junk cars. We have dumped industrial waste into our water to be carried out of our sight. Out of sight, out of mind!

That's why Congress established legislation 25 years ago creating a Federal–State partnership to ensure strong and appropriate State water quality standards. At that time, the Federal Water Pollution Control Act was the sole Federal basis for water pollution control and enforcement. The Federal Government approved the first State standards in 1968. Since that time, States have made great progress in adopting and developing chemical-specific criteria. We are still trying to get some States to move forward with that job! But, we have made progress—progress largely attributable to the partnership among all of us—cemented by our vigilant efforts to protect water resources.

With these tools, along with others now afforded to the Federal Government and States, we have seen significant, meaningful improvement in water quality. Just this month, there was a celebration of "The Healing of the Potomac." At this event, the Smithsonian opened a marvelous exhibit that vividly portrayed the process.

The Potomac, which is just up the road from us here, was very troubled, largely from untreated sewage and nonpoint runoff, as are many other rivers across the country. In 1965, President Johnson labeled the Potomac "a national disgrace." People who lived here avoided the riverfront because of the stench and disease associated with its gross pollution. However, armed in part with Clean Water Act authorities, the Interstate Potomac River Basin Commission, with lots of Federal, State, and local effort, helped turned the tide.

Today, the Potomac is filled with fish and other aquatic life. Sixty to 70 percent of the Washington metropolitan area can rely on the river for safe drinking water. There is a renaissance of recreation and economic activity on and near the Potomac. In 1990, both President Bush and Justice Sandra Day O'Connor caught fish from the Potomac. (The president's was a three-pound bass.) Bass anglers say that, over the last few years, the largemouth bass fishing in the Potomac has been among the best anywhere in the Nation. There are many other examples across the United States where Federal, State, tribal, and local efforts report similar progress. And it has been awhile since anyone has reported seeing a river on fire.

Remaining Problems

But is our work done? Are the Potomac and other waters of the United States completely healed? We can catch fish again, but are they safe to eat?

Development along our waterways brings its own set of water quality problems. We need new approaches to meet today's challenges. As Oliver Wendell Holmes wrote: "I find the great thing in this world is not so much where we stand, as in what direction we are moving...We must sail sometimes with the wind and sometimes against it—but we must sail, and not drift, nor lie at anchor. "

Nonpoint Sources of Pollution

So it is time to set our sails for new directions. Pollution persists from diffuse sources such as stormwater runoff from agricultural and urban areas. State-reported water quality information tells us that nontraditional sources of pollution, especially nonpoint sources of pollution coming from diffuse areas and land use activities such as farming, timbering, and construction, are now the leading reasons for water quality problems. We are also learning more about subtle risks to aquatic ecosystems and human health resulting from toxic chemicals and developing ways to address those risks.

Toxics

Toxic contamination in the environment is one of the greatest problems facing the United States today. Toxic substances such as PCBs and dioxin have been discharged and dumped in our rivers, where they remain and accumulate in the sediments and benthic communities, posing risks to aquatic life, human health, and wildlife from fish consumption. Reports indicate that elevated levels of toxics exist in one-third of monitored rivers, lakes, and coastal waters. Ninety percent of assessed shorelines around the Great Lakes have elevated levels of toxics. And toxics aren't always easy to identify or control.

Congress, recognizing the critical risks toxics were posing, reinvigorated our efforts in this area by passing new amendments in 1987 to the Clean Water Act that required States to adopt numeric toxic water quality standards. Some States have worked hard over the last three years to meet the 1987 Clean Water Act requirements. It's been a tough job of great importance—a job that a disappointing number of States have not completed. While the States move on with their efforts, we at EPA are preparing a proposal to establish Federal toxic standards to apply in those States that have not adopted their own criteria.

The effort to finally establish water quality standards for toxic pollutants is essential to the success of a number of Clean Water Act programs and objectives, including permitting, enforcement, fish tissue quality protection, coastal water quality improvement, prevention of sediment contamination, certain nonpoint source controls, pollution prevention planning, and ecological protection. There has been no higher water quality standard program priority for the past year. We have devoted extensive staff and management resources at both headquarters and the regions to assist States in developing draft standards and to prepare the Federal proposal for States with deficient programs. We are fully committed to do what it takes to bring this effort to a successful conclusion. I heartily urge you to continue to ensure that your State has adopted its own toxics standards. Until every State has all necessary numeric water quality standards for the toxics for which EPA has promulgated numeric criteria, our work in this area is not done!

Sediment Criteria

Another area of serious concern is the impact of contaminated in-place sediments. In many locations, in all types of waterbodies, contaminated sediments are degrading the chemical, physical, and biological integrity of the water. Contaminated sediments represent the legacy of our past industrial waste disposal practices as well as ongoing urban and agricultural runoff. EPA is establishing sediment criteria that will help us to establish regulatory thresholds for these contaminated areas. We need the criteria to guide us in preventing other pollution and determining whether these unacceptably contaminated sediments can recover through natural processes or should be removed from the Nation's harbors and water systems.

Wetlands Water Quality Standards

We also are focusing on water quality standards for wetlands to ensure that provisions of the Clean Water Act currently applied to other surface waters also are being applied to wetlands. We recently issued guidance entitled, *National Guidance on Water Quality Standards for Wetlands*. By the end of fiscal year 1993, the Agency intends that each State will have included wetlands under its definition of "State waters," established beneficial uses for wetlands, adopted wetlands-related narrative biological criteria, and applied antidegradation policies to wetlands. Since all of these topics are subjects of these sessions, I'll move on to talk about broad Agency themes that are the focus of our water quality standards.

On Risk

The first theme is risk-based priority setting. We are learning more about the existing risks to our environment and which ones we will likely run aground on if we fail to heed the warning signals. Under Administrator Reilly's leadership, we at EPA have concluded that we can no longer send out the Navy, ship-by-ship, on isolated missions. We must assemble the fleet on a collective assignment targeted to the greatest environmental risk.

The Administrator has made a commitment to risk-based choices in environmental protection. A report, *Reducing Risk: Setting Priorities and Strategies for Environmental Protection*, was recently released by EPA's Science Advisory Board. We in the water arena will have a critical role in responding to this report. The Science Advisory Board, made up of non-EPA scientists and experts, identifies issues such as habitat alteration and destruction (including wetlands losses), loss of biological diversity, and contaminated drinking water as relatively high-risk problems. Protection of our water resources will obviously remain an extremely vital task.

The report also includes a meaningful discussion of the extraordinary value of natural systems. It calls on the Agency to afford equal protection to both ecosystems and public health. We must give greater recognition to the vital link between human life and natural ecosystems. The Office of Water is attempting to do this in part through a new emphasis on biological, habitat, and wildlife criteria. Our future course into the 21st century will be to treat rivers, streams, estuaries, and wetlands as integrated ecosystems, intrinsically worth protecting for their own sake, and for ours.

Better Science

The development of a solid scientific and technical foundation is another Agency theme at the heart of establishing sound water quality criteria and standards. As we improve our science, we must also improve our ability to translate this knowledge into practical tools that can be easily used to help establish the environmental ethic we want to instill in our decisionmaking process.

Geographic Targeting

We at EPA believe geographic targeting of priority watersheds will be the direction of the future. We are committed to this approach in the Office of Water. Our commitment does not mean that we will neglect our base programs. We will have to find a balance between addressing nationwide program requirements and adopting geographically targeted approaches for sensitive, threatened, or degraded areas. Geographic targeting will provide us with a framework to tackle the difficult and resource-intensive management problems of nonpoint source pollution, stormwater runoff, and habitat protection. And we must better integrate our efforts as we do this targeting.

Integrated Efforts

As Aldo Leopold said almost 50 years ago in his *Sand County Almanac*, "Instead of learning more and more about less and less, we must learn more and more about the whole biotic landscape." We must all look at every effect of our human actions and use our tools in concert, not piecemeal.

You will be discussing one of the United States' finest ecosystems, the Great Lakes. These five lakes will serve as a national laboratory to learn what is possible through multimedia, geographic targeting. The Agency, recognizing the need to look at all sources of pollution entering these waters, initiated the Great Lakes Multimedia Program under the leadership of Administrator Reilly. In the Great Lakes, we will break the mold of traditional pollution control and cleanup programs. Our multimedia efforts in the Great Lakes will pave the way we intend to go in the years ahead. Not just the water program but also the air, waste, toxics, and pesticide programs will unite to tackle remaining problems impairing lake water quality.

Pollution Prevention

Pollution prevention, the final Agency theme, will be among our most effective tools in the coming years. We can no longer be content to set standards, apply them in permits, wait for violations to occur, and then take enforcement actions.

Today, I'm glad to say, we do have better than a 90 percent major municipal compliance rate, and it is even higher for major industrial sources. But we must improve our early warning systems to identify facilities on the path to trouble and mobilize industry to switch processes and produce fewer (and less damaging) waste by-products. Individual citizens must be mobilized to limit use of fertilizers on lawns and gardens; properly dispose of used oil, batteries, and paint cans; switch to less harmful cleaning substances; and recycle paper, glass, and aluminum. We must generate less pollution as a Nation.

Conclusion

So, as we approach the 21st century, our work is not completed. For the tough problems that remain, we must change the way we think and act. All State water quality standards must soon include criteria for toxics or else they will include EPA-promulgated standards. We must prevent pollution, not just clean up after we have fouled our rivers and bays. We must work in concert with each other, focusing our efforts on problems posing the highest risks and in geographic areas where we can realize the greatest risk reduction.

In responding to the Science Advisory Board's report recommendation to pay equal attention to ecosystem risk, we must continue our work on establishing biocriteria, wildlife criteria, and other related science. We must think holistically and act comprehensively. There will be challenges, but we must meet them. We must succeed because we can't afford to fail.

State Perspectives on Water Quality Standards

Bruce Baker
Director, Water Resources Management
Wisconsin Department of Natural Resources
Madison, Wisconsin
—and—
Chairman, Association of State and Interstate Water Pollution Control Administrators
Water Quality Standards Task Force
Washington, D.C.

Introduction

Before I begin my remarks, I want to reemphasize some points made here today. I agree almost word for word with everything both LaJuana and Martha said. The one point that I will keep making is that the States are major actors in this effort. It is important to remember our role as partners in the implementation of water quality standards.

As you know, the water program across the country has shifted over the last decade. We have moved away from a technology-based approach, where most of our efforts were focused on secondary treatment, best available technology, and technological approaches, to one that is based on water quality standards. That shift is occurring in relatively different time frames across the country, on a State-by-State basis, and, in some cases, has caught States—and dischargers—by surprise.

Many of the things you're talking about are active issues in the States; in fact, all these issues come up routinely when States get together to talk about water quality standards. One issue that continually recurs in those discussions is the States' hesitation to adopt standards in situations where EPA has handed down draft regulations or guidance that will be subject to change. Both situations put States in a difficult position; they can go through a lengthy, expensive adoption process (sometimes up to three years before a final rule is in place), only to have the national guidance or approach change.

Challenges to water quality standards and permits based on them have increased dramatically. Challenges to the implementation of new standards, which are very common, have aggravated the States' workload. Not only is it difficult to put those standards in place, but it is a tremendous job to defend and sustain them during the implementation and permitting process.

During 1990, EPA headquarters and regional staff conducted forums that involved 37 States. In those discussions, the lack of final guidance was brought up as a critical issue. A theme that came out of those forums was that EPA seems to be using different approaches, particularly for regional interpretations of standards. We, as States, would like to work with EPA to try to narrow the problems associated with that issue. We will never reach a time when all the regions will take identical approaches to every issue, but we need to strive toward greater consistency across the country.

The States' "Christmas List"

Since this is the holiday season, I have prepared a Christmas list from the perspective of the States.

- One area that is on the States' list is their need for a final policy on which forms of metals should be used in the definition of water quality standards. The majority of States would urge EPA to adopt an acid-soluble method for metals analysis and allow it to be used to measure compliance within National Pollutant Discharge Elimination System (NPDES) permit limits for metals. The States also need a better method for metal analysis; examples for that might be mercury as well as some selected organic compounds.

- Second on the list is mixing zones, an area where clearly we need guidance that will provide additional clarity and a more defensible position for their application and use. We are not necessarily calling for a greater use of mixing zones but need some clarity on where they are appropriate (particularly important because of the impact mixing zones have on the application of toxic limits). States also need better guidance on the zones of initial pollution.

- Not only are we looking at a shift where numeric standards drive permit programs but also to a new concept: applying antidegradation in situations where States are already meeting water quality standards. It has taken a great deal of time for some people to understand that concept; therefore, we must continue to work with EPA to define what antidegradation implementation means and establish specific implementation procedures. Although some States have moved ahead in this area, we need to have a continuous sharing of some of the successes and failures. Clearly, everyone must understand that we're talking about a narrative standard that would apply in situations that are beyond the numeric water quality standards. An example of the use of antidegradation is the control and limitation of persistent bioaccumulating substances in the Great Lakes.

- Next on the list is economic impact analysis. Everyday, economic impact is an issue for States, either in the adoption or implementation of water quality standards. The draft revisions to the water quality standards handbook contain a discussion on economics that is somewhat helpful, but we need a final version with additional information on applying discharger-specific variances and implementing related antidegradation policies.

- EPA has targeted biological criteria in wetlands as a priority in the next triennial standards review. Therefore, we need a final, expeditious completion of the "Biological Criteria Technical Reference Guide" and "Wetlands Use-Classification Methodology Summary" from the Agency.

- We would urge EPA to take a serious look at moving beyond the outdated approach for PCBs that is currently used across the Nation.

- Dioxin is an issue everyone is familiar with. Many States think the range of acceptability in dioxin numbers is too great. We understand EPA's position on this issue and the scientific debate, but the bottom line from the States' perspective is that the range of acceptability places a great burden on States to defend numbers that are significantly different across the country. This creates tremendous problems in terms of consistency in interstate waters and from region to region across the country. This is an area where we need to talk about other things that should be taken into account when standards are adopted—particularly issues such as the right public policy associated with some of these standards. Sometimes the numbers have to be complemented with public policy debate on the changes and the situations they create.

- Approaches to dealing with ammonia differ greatly across the country. EPA and the States must solve the root problem associated with ammonia to develop greater national consistency.

- States attach great importance to the development of sediment criteria and are pleased to see that EPA also regards this as a priority.

- One of the problems that States face continually is having a completely different number end up in a permit as a result of different implementation procedures that exist from State to State. You can have the same standard but end up with totally effluent-limit requirements based upon those implementation procedures. States think EPA should focus on this area and produce more specific guidance on implementation procedures. Water quality in-take credits, limit of protection, limit of quantification, compliance with water quality standards, and the four-day, once-in-three-years compliance for chronic aquatic life criteria are a few examples of some areas that are day-to-day problems for States.

- More thought needs to be given to the use of water quality standards for some nontraditional areas. As nonpoint sources are increasing in importance and getting more attention in the States, we need more dialogue on the use of water quality standards for all these problems, including stormwater.

- Water quality standards should be developed for lakes. This is a major gap because inland lakes are important resources for many States.
- Generically, a big problem is cross-program communication on water quality standards. We need better internal coordination within EPA and the States on use of water quality standards for programs such as Superfund. How these standards apply and come into play for air deposition situations are just two examples that must be explored further to make sure that new water quality standards will not be used just for the NPDES but will apply across the board.

The States and EPA

The States are not interested in just identifying problems; we also want to participate in developing solutions. In the last two years, there has been a shift in State discussions: the majority of States want tighter, more specific guidance from EPA on water quality standards, even at the expense of flexibility. Some States have even said that they are willing to have EPA adopt their water quality standards, which is something I don't think you would have heard five years ago.

EPA has made standards a higher priority, which States believe is critical because of the workload associated with them and their importance. We would like to see more resources for the development of water quality standards and more efforts toward the States' adoption process. We would like to stress EPA's early involvement in the adoption of water quality standards as opposed to the Agency waiting until the package is completed some two years later. It is much easier to respond to EPA's views earlier in the process.

We also need help in defending those standards. Because there are a growing number of challenges to water quality standards, the States would like to have a partnership role in defending them.

EPA should place a higher priority and more resources on a national clearinghouse that will facilitate technology transfer between the States on water quality standards. More information is needed on the standards—their adoption, successes, and also their failures.

EPA researchers should be involved in the implementation of water quality standards. What we really are referring to here is a feedback loop, so that research staff can see how standards are implemented and what type of problems arise out of their development. I think the States would be willing to assist in that process. That feedback loop could be critical to a successful standards program. An implementation component would be part of each standard guidance package so that recognition of implementation issues is addressed up front as the different packages come out.

I'll probably regret saying this, but States really want to see greater risk-taking in standards development. Sometimes guidance that's based on EPA taking a risk is better than no guidance at all. The States are willing to work with EPA, to encourage the Agency to take some risk and, instead of implementing new policy on a case-by-case or State-by-State basis, go forward with a consistent national approach.

We are also willing and anxious to work with EPA to set priorities for the future. Critical to that are schedules. We must be in concert on the schedules for EPA's issuance of guidance so we can plan our work at the State level. I also want to encourage EPA to sponsor more technical symposia related to water quality standards.

One of EPA's roles that is sometimes neglected is emphasizing uniform standards for interstate waters. Because water quality standards are such a driving force in the programs today, greater attention must be paid to how we resolve differences on interstate waters. This is a problem that has led States to support the need for better national guidance.

Lastly, States should be involved to a greater degree in the development of water quality standards. An example of that is the Great Lakes Initiative, where the States are taking a lead in in developing water quality standards for the Great Lakes.

Conclusion

In closing, I want to recognize the importance of water quality standards. But we still need to take advantage of technology-based approaches such as best available treatment technology and not just focus on water quality standards. As States, we applaud EPA's recent progress on and attention to water quality standards. If LaJuana Wilcher were here, I would thank her for attending to the States' issues and spending time with States at some of the national association get-togethers.

The States are major actors in this effort. We are involved not only in developing water quality standards but also in their implementation. We are committed to working together with EPA and the other partners in the water quality program to make these standards happen.

Questions, Answers, and Comments

Q. *Comment about taking risks in the development of water quality standards.*

A. One of the examples from the regional perspective is that we could spend more time trying to flush the specific scientific issues associated with PCBs as an approach for water quality standards. There comes a time when you have to take the risk. Maybe you don't have as much science as you would like but enough to push the issue forward by not waiting for another round of technical discussions. Clearly, we are interested in basing standards on sound science, but it isn't there for everything. States are often put in the situation where they have to adopt standards without either complete EPA guidance, good science, or all the necessary science. We take those risks and want to encourage EPA and the national guidance to take some.

Q. *(Harlan Agnew–Pima County, Arizona) We heard the suggestion that water quality standards should be developed for lakes. Is there anyone from EPA who would like to comment on water quality standards for dry washes?*

A. (Martha Prothro) It is a very difficult issue. We have to deal with a flow and a trade-off between chemical or biological integrity of a waterbody. When dischargers are making decisions about whether to stop discharging, they are thinking of totally killing the stream (because the discharge makes the stream). These are difficult choices. I can't predict what EPA is likely to do in this area.

We have a number of issues before us that relate to flow and some of them are not dry washes issues. In the San Francisco Bay Delta, we have some with regard to diversions of flow to agricultural and urban sections in southern California. If we are going to apply the Clean Water Act vigorously in the arid West, these are issues we will have to grapple with over the next few years.

Q. *Please comment on taking the risk of considering biomonitoring as a higher priority in chemical criteria when there is conflict between the two.*

A. (Martha Prothro) It is important to point out the chemical if aquatic criteria for life protection were, in fact, based on biomonitoring, so there is not necessarily an inconsistency. We cannot expect ever to be able to cover every chemical that could get into the water and set a chemical-specific number for it; therefore, we will always want to have some kinds of biological approaches: biological effluent monitoring, biomonitoring, ambient conditions, and ecosystem reviews to determine whether or not there is a balanced ecosystem in a specific watershed. Our policy published in 1984 still holds that we see the water quality program as being a three-legged stool made up of technology-based standards, biomonitoring, or whole effluent-type approaches and chemical-specific standards. They are all necessary. The chemical-specific standards are probably the most obviously necessary to protect a drinking water supply or protect against fish contamination that could affect human health. In those cases, where we have pollutants of concern that are biocummulative, there isn't any alternative to setting chemical-specific numbers, but I think they are equally important.

Q. *(Victoria Binetti–Region III EPA) Mr. Baker, please speak to your comment that you would like to see EPA put greater emphasis on uniform standards for interstate waters.*

A. (Bruce Baker) The Great Lakes States are frustrated because each one of the Great Lakes has different standards because different States surround that particular lake. That case is a good example of the leadership role that EPA can take in facilitating discussion among all the parties toward developing uniform guidance for those interstate waters. It will take reprioritization within Regions V and II and some resources to make that happen, but it is an example of what needs to happen in other interstate waters before we can resolve differing approaches and numbers that are naturally occurring because of state-by-state development of water quality standards. For us, the Great Lakes is a priority place to begin that issue, at least for the Midwest, but it's also an initiative that goes beyond the Midwest.

C. (Dick Schwer–Du Pont) The regulatory community, particularly industrial municipal dischargers, should be considered full partners in this effort to improve our waters (even future waters) and establish a program that will meet everyone's needs for clean water.

Q. *(Bruce Baker) What role will industry have that it doesn't have now?*

A. (Dick Schwer) The regulatory community should be involved at an earlier point in the process of developing regulations, particularly on the EPA level, so that the input from this segment can be factored into the decisions that are made earlier on. Then later on there won't be a tendency on the part of some people to resist those regulations because they haven't had a chance to participate in the process.

C. (Martha Prothro) As I read LaJuana's speech, I thought, there is one constituency here that isn't on this note; however, I don't think it was intentional because she probably wasn't aware of how many industry people were participating in this conference. We didn't have much of a turnout from industry at the last one, so we welcome all of you. I think it is healthy to have a good dialogue here. We frequently publish draft criteria documents for comments early in the process before States are required to develop standards based on these criteria, and it surprises me how little participation we get in that process, how few in the regulated community and academia, for that matter, provide comments. So I urge those of you who now are beginning to feel the difficulty of facing and complying with the standards to pay more attention in the future to the criteria documents that are published in draft. Send us your comments. Any data will be very much appreciated, including information on impacts.

Q. *I'd like to respond to your point about availability of draft documents. We have participated when we learn that draft documents are available, but the procedures for distributing documents need to be improved. I recommend that you put them in the Federal Register for a 45-day review period and distribute them widely. For instance, to the mailing list for this conference. The draft document simply has not been distributed very well. I say that as chairman of an organization that represents more than 70 other organizations that often do not receive any information.*

A. (Bruce Baker) The notices for the criteria go through a public comment period. The guidance documents are published in the *Federal Register*. Maybe the issue here is that we haven't been putting out water quality criteria in the last couple of years. We are trying to encourage people to get involved earlier in the process proactively. We don't want to deal with a lot of these science issues at the tailend of the process when criteria are being adopted if we could address them earlier on; it's easier, quicker, and better for all to be involved in the process, and we'll continue to try to involve all who are interested as early as possible.

Q. *(Mike Pifher–Colorado Springs) In developing your policy on hydrologic modifications as they impact wetlands and water quality standards downstream, what consideration are you giving to the prior appropriation of States and the impact on water rights?*

A. (Martha Prothro) We must pay a great deal of attention to that issue. The Clean Water Act specifically provides that we have to be careful about water rights throughout this entire process. I think we have been sensitive to it, although we may not always agree on where we come out on these issues.

Q. *(Paul Crowhart—Colorado Water Quality Control Commission) I was struck by a difference in the list provided by Martha (and some of her comments) and the prospective State lists in terms of potential areas for clarification in the water quality standards program. EPA listed all areas, while the State list was much more of a combination: some new issues but a lot of the old areas such as metals analysis, mixing zones, and ammonia. The metaphor of a Christmas list is apt. EPA has a tendency each year to play Santa Claus and bring us a lot of exciting toys; however, some of us aren't done playing with the old toys, and some haven't figured out how they work yet.*

C. A lot of implementation issues are coming to the forefront now as States are adopting toxic standards. We are aware that these issues need attention; we are hearing this from our regional offices as well as the States. I'm not sure I can address everything on Bruce's list; however, we are very concerned about a great many of these issues.

C. (Edwin B. Erickson) Part of the logic that underlined the reorganization of the Office of Water is to improve our ability to deal with some aspects of implementation that, in the past, have been secondary, and, by having an organization devoted to those types of things, we might be able to do our job better.

TOXIC POLLUTANT CRITERIA

Toxic Pollutant Criteria: The States' Perspective

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Introduction

States often find themselves sandwiched between the proverbial rock and hard place when dealing with U.S. Environmental Protection Agency (EPA)-generated toxic criteria and regulated dischargers. During the last 20 years, many of us in water quality management have become comfortable with traditional chemical-specific criteria for many reasons, including but not limited to the large amounts of chemical data, our experience in measuring small amounts, quality assurance, and reproducibility of results.

Toxicity Testing

Such is not the case with toxicity testing. Most toxicity tests are performed at numerous dilutions to statistically determine effluent concentrations that will kill 50 percent of the test species. Variations on this theme have led to the concept of whole effluent toxicity testing as a permit parameter. However, researchers (most recently Warren-Hicks and Parkhurst, 1990) have determined that extreme variations occur in individual toxicity tests. Even with multiple dilutions, toxicity testing varies 20 to 30 percent or more depending on the species used. Mortality can vary by as much as 100 percent at a single dilution; therefore, a 10 to 20 percent mortality should not be considered a reliable indication of toxicity.

Missouri does not believe in incorporating toxicity units into permits, preferring to think of toxicity as a condition, not a quantity. Biological tests are considered most useful as screening procedures that point to effluents or conditions where more chemical testing is needed. Recently, Missouri's Department of Natural Resources participated in a water quality-based permit quality review performed by EPA Headquarter's Permits Division, which stressed Title 40 of the Code of Federal Regulations 122.44 (d): where adequate information exists to show that a reasonable potential exists, toxicity limits must be placed in permits. However, placing these limits presents problems because permittees do not always have ready access to toxicity testing contractors and few testing laboratories in Missouri have successfully mastered the technique of rearing *Ceriodaphnia dubia* (water fleas). More than once toxicity test summaries have shown 100 percent mortality in the control.

An EPA-funded study by Battelle (DeGraeve et al. 1989) verified this concern when it found that some highly regarded laboratories were having trouble completing bioassay tests successfully from the standpoint of getting both acceptable control survival and fecundity and enough test organisms of the proper age to complete the test. Thus, anyone who performs the test will probably use a laboratory that will have difficulty running it, which translates into higher testing costs for permittees, greater numbers of test failures, and an increased tendency to fake test results to keep from doing additional tests or repeatedly report test failures.

The State has been told to use multiple species when identifying the one that is sensitive to the effluent. Paraphrased, this seems to encourage laboratories to pick a species that will not survive an effluent toxicity test. EPA acknowledges that rainbow trout are not suitable test species for warm-water streams; however, *C. dubia,* typically a lacustrine species, is just as inappropriate for small midwestern streams that drain agricultural watersheds.

Whole effluent toxicity testing is still in its infancy, as are other biological measures. Some day biocriteria and other tools to evaluate biological integrity will be available, but many concerns must be addressed before the regulated community should be required to comply with these water quality measures. Therefore, States should be cautious when grappling with recommending toxicity reduction evaluations, which can cost up to $100,000 and therefore should not be applied indiscriminately. It is nearly impossible to do toxicity reduction evaluations on discharges that are toxic infrequently or episodically. One failed toxicity test is of limited value, as is one discharge monitoring report that shows a one-time exceedence of a permit limitation.

Fortunately, there is a growing body of information on persistence of toxicity once it enters the stream. Initial findings of some studies indicate that physical factors such as riffles and a high amount of water-substrate contact can substantially reduce toxicity. These data certainly have implications for dischargers to small streams.

304(a) Criteria

As for 304(a) criteria and their applicability to States' water quality standards, while Federal water quality criteria as published in the *Gold Book* (U.S. Environ. Prot. Agency, 1986) have sound scientific basis, many of my counterparts in other States would agree that wholesale acceptance by all State and river basin water quality management agencies could be unwise for the following reasons:

- There is little likelihood of finding some of these pollutants in water. Sometimes, the analytical detection limits are above the recommended criteria.

  During Missouri's last two triennial standards reviews, the issue of detection limits came up frequently. Our rationale for adopting such low values is based on establishing permits for National Pollutant Discharge Elimination System (NPDES) outfalls to large rivers such as the Missouri or Mississippi. However, our attempts to determine attainment of in-stream criteria will lead to check marks in the "unknown" or "undetermined" columns of 305(b) until laboratory analysts can measure extremely small quantities of some of these materials.

- Another dilemma involves background concentrations of substances that turn up in the water column as a result of weathering. Missouri has several waterbodies—the Missouri River in particular—that, because of natural conditions, are known to exceed suggested *Gold Book* limits for mercury, arsenic, and beryllium. Ambient fixed station monitoring also shows dissolved lead to be two to three times higher in Ozark and prairie streams than in Missouri's two major rivers.

Recalculation of the Nation's database is one viable alternative to wholesale acceptance of suggested EPA criteria, particularly when sensitive species that are not native to the State are used to develop the recommended numbers. EPA has pushed development of fish consumption criteria, leading to questions of how States should make this determination.

Fish Consumption Criteria

Fish consumption criteria should only apply to those waters that are likely to produce edible fish on a somewhat constant basis (that would allow for a 70-year exposure). Missouri is proposing to include 10^{-6} fish consumption numbers to all aquatic life protection waters and is seeking comments on the propriety of this action. Since many fish consumption criteria are based on consumption rates of 6.5 grams per day over a 70-year lifespan, these human health protection numbers should not apply to small streams that cannot support fisheries of sufficient magnitude to provide a 70-year supply of edible fish for one person.

Another apparent dilemma in this area relates to the use of raw fish as the basis for some of the fish consumption numbers. Cooking undoubtedly has some impact on the concentration of certain substances in edible tissue, but there has been little information that would indicate that this breakdown or decay was considered in the calculation of human health criteria that are intended to protect for both drinking water and fish consumption uses.

Research Priorities

Is more research needed on toxic pollutants? My answer is a definite yes. Priority should be given to chemicals that are precipitating regular actions—typically trace toxicants that are believed to be a problem for long-term health. Some chemicals that come to mind include dioxins, dibenzofurans, chlorinated hydrocarbon pesticides, PCBs, THMs, and commonly used pesticides. Priority toxic pollutants are not the correct focus of EPA and State activities. The list of 129 priority pollutants is close to arbitrary. In Missouri, more attention should be paid to atrazine, alachlor, and diazinon than butylbenzyl phthalate.

Water supply companies on the Missouri River are anxiously awaiting (or dreading) a new atrazine criteria. Since the States to the north and west of Missouri are major atrazine users and water samples routinely exceed the proposed standard, particularly during spring runoff, Missouri's Department of Natural Resources is once again thrown into the unpleasant situation of reporting new non-attainment waters as a result of criteria written in Washington, D.C. And, unfortunately, we're still scanning for 3,4, benzofluoranthene and hexachlorobutadiene and coming up with non-detects.

There are several appropriate sources of information for determining those pollutants that deserve greater attention than the list of 129. They include:

- NPDES application forms and discharge monitoring reports,
- Analysis of Toxic Release Inventory data,
- Follow-up chemical monitoring toxicity identification evaluation after failed toxicity tests,
- Investigation of fish kills,
- Pesticide use survey, and
- Ambient monitoring.

Data quality is the obvious drawback to using these surrogate measures. Sources of information can vary. We have all been frustrated too many times by a priority pollutant scan that showed "not detected" for 128 substances and an exceedence for methylene chloride.

When considering Toxic Release Inventory information, data applicability becomes quite relevant. Much to our chagrin, Missouri discharged more toxic chemicals to public sewage treatment plants in 1988 than any other State, primarily because one inorganic pigments industry discharges to the St. Louis Metropolitan Sewer District. Routine and required toxicity testing by the District, however, has never shown that specific pollutant to be a problem, particularly in concentrations that result after mixing in the Mississippi River.

Changes in Missouri's Standards

Missouri has had some difficulties in implementing some of EPA's desired toxics guidance issues, and while this presentation has pointed to some of the problems that need attention, recent changes to the State's water quality standards regulation should be effective in accomplishing State and Federal water quality goals. These recent changes include:

- Addition of aquatic life and human health criteria that would bring the State into compliance with 303(c)(2)(B);
- Addition of 70 miles of "outstanding State resource waters," including two unique wetlands;
- Application of technical support document (U.S. Environ. Prot. Agency, 1985) provisions regarding mixing zones and toxicity identification;
- Inclusion of wetlands and appropriate numeric criteria for their protection.

We still have some work to do on implementation policies that are necessary to carry out the provisions of these standards, but I am confident that, working with EPA Region VII staff, we will achieve our mutual goals.

Conclusions

In closing, here is a local experience involving application of toxics criteria that involves the wise or unwise expenditure of dollars to protect the public: repainting bridges over large rivers. In St. Louis, the State Highway and Transportation Department was under fire recently for allowing sand blast residue and paint chips to fall into the Mississippi River. When asked if this activity was consistent with State water quality standards, Missouri's Department of Natural Resources' first thought was to perform a simple wasteload allocation study. The following five-step rationale was applied:

1. A conservative estimate for flows in the Mississippi at this time of year is 50,000 cubic feet per second.
2. We rounded an estimated 184 cubic feet of paint off to 200.
3. We assumed that the paint to be removed was 100 percent lead, although analyses showed 20 percent.

4. We estimated that the project would take 100 working days at eight hours per day.
5. We allowed one-tenth of the river's flow to be used as a mixing zone as per EPA's technical support document (U.S. Environ. Prot. Agency, 1985).

The following reasoning was then applied:

- Two cubic feet of paint dust, flakes, and chips will mix with 144 cubic feet of water in the course of an eight-hour day.

- If this is elemental lead and all of it goes into solution, there is still only 14 parts per billion in the water column.

- Since our existing criteria for drinking water sources was 50 parts per billion of lead and our chronic aquatic life protection limit for general warmwater sport fisheries was 29, painting the bridge seemed like a perfectly legitimate and approvable activity.

Not so. Since the paint chips went on to flunk an EP toxicity test extraction procedure under Federal and State Resource Conservation Recovery Act provisions, they were determined to be hazardous waste. The State has to catch and bag the paint chips and transport the waste to an appropriate landfill.

So much for toxics criteria and the Clean Water Act.

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Toxic Pollutant Criteria—Industry's Perspective

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Introduction

The U.S. Environmental Protection Agency (EPA) needs to address industry's concerns about regulation of toxic pollutants. The Agency should encourage State water quality standards that support high quality surface waters yet enable environmentally responsible industrial discharges.

As an environmental engineer for Du Pont for nearly 20 years, I take pride in my company's efforts to improve the quality of its discharges. Du Pont has expended considerable resources to install treatment facilities, monitor effluents, and conduct environmental studies of the surface waters it enters.

What Has Been Done?

Let's review what industry has done to control toxics in discharges. Both Du Pont and the Chemical Manufacturers Association (CMA) have been involved in developing comments on criteria documents that grew out of the 1965 Clean Water Act (the *Green Book* in 1968, the *Blue Book* in 1973, and the *Red Book* in 1976), and for years we have participated in developing toxic pollutant criteria. From 1978 on, as EPA produced water quality criteria documents for 307(a) priority pollutants, CMA and many of its member companies submitted comments. The chemical industry also has been involved with incorporating criteria into State water quality standards by providing comments, often through State chemical industry councils.

Industry has made substantial progress in reducing toxic pollutants from point source discharges. Many industries have installed biological treatment facilities to reduce biochemical oxygen demand and total suspended solids in surface waters, which has had the additional benefit of removing significant amounts of toxic pollutants from effluents.

More directly, many industrial sites have reduced priority pollutant discharges to comply with EPA's technically based effluent guidelines and pretreatment standards. Certainly for the chemical industry, compliance with the 1987 EPA organic chemicals, plastics, and synthetic fibers regulations over the next few years, as permits are renewed, will achieve additional reductions.

Moreover, still further reductions in toxics can be expected through recent EPA and State initiatives. Compliance with section 304(l) requirements for individual control strategies will reduce toxics from point sources that States and EPA have declared are affecting certain waterbodies. These waters are still not expected to achieve water quality standards for priority pollutants even after the best available technology that is economically achievable is applied to industrial discharges. These strategies must be met in June of either 1992 or 1993, depending on the selection method.

The original list published by EPA in June 1989 included 625 industrial sources but has since been expanded. Specific dischargers have challenged certain of these determinations, which in some cases were made with little data.

With broader impact, States are moving at an accelerated pace to include section 307(a) toxic pollutant criteria in their water quality standards in compliance with the Clean Water Act, section 303(c)(2)(B). Most are greatly expanding the number of toxic pollutant criteria included in standards that dischargers must meet when renewing discharge permits.

To assess what has been done and what still needs to be accomplished, you could consider the available information on the current status of toxic pollutant problems in surface waters. Unfortunately, these data are limited since they don't cover all the potential adverse effects of toxic pollutants in aquatic ecosystems. However, a review of existing data can provide perspective on the toxic pollutant problem and, indeed, may surprise you.

The National Water Quality Inventory

The most recent National Water Quality Inventory, published by EPA in April 1990 (U.S. Environ. Prot. Agency, 1990a), contains general information on pollution causes and sources in rivers, lakes, and estuaries that was presented by the States in their section 305(b) reports for 1988. The EPA inventory shows that siltation and nutrients are the leading pollution causes in rivers and streams. In categories that would include toxic pollutants, metals and pesticides are the fifth and sixth most commonly reported pollution causes. Industrial pollution ranked seventh among the sources of river and stream impairment. For lakes and reservoirs, nutrients and siltation again led the list of pollution causes while organic priority pollutants, metals, and pesticides were ranked seventh, ninth, and tenth, respectively.

Among the pollution sources mentioned for lake impairment, industrial sources ranked sixth. In the data provided on estuaries and coastal waters, nutrients and pathogens were the leading causes of pollution, with metals, organic priority pollutants, and pesticides ranked fifth, eighth, and ninth. For estuaries and coastal waters, industrial pollution was seventh on the list of sources mentioned.

Some implications can be drawn from this information. It indicates that:

1. Progress has been made in reducing the acknowledged toxic pollutants to surface waters, and
2. Industry is not among the major sources of pollution being identified by States.

This is a limited data set. It only addresses water column toxics information; neither aquatic organism residues nor sediment quality are mentioned directly. This does not imply that toxics are <u>not</u> a problem—only that they need to be viewed in the context of resolving <u>all</u> the identified problems impairing surface water uses.

Nonpoint sources are clearly the major cause of pollutants impairing our Nation's waters. According to most recent State data, nonpoint source pollution is looming as an increasing concern that must be addressed if we are to make a step-change improvement in overall water quality. Although EPA continues to work on the difficult task of developing stormwater regulations and States are beginning to develop best management practices, much more must be done to control nonpoint sources of toxics and other pollutants.

What Still Needs To Be Done?

While much has been done to reduce priority pollutants from point source discharges, water quality problems from toxic pollutants still exist in some waterbodies. We need to learn more about the fate and effects of toxic pollutants and how to better assess risks to human health and the environment. Many other critical issues relate to toxic pollutant criteria. Some that are of particular concern to industry, including issues related to the translation of toxic pollutant criteria into discharge permit limits, are addressed in the following paragraphs.

Comprehensive National Database

The United States must develop a comprehensive national database for toxics in surface waters that shows status, trends, and effects. The data received from the States are not complete; furthermore, the States are not consistently reporting whether beneficial uses for surface waters are being met. Although limited, these State results have value since they usually come from areas of greatest concern, such as industrialized waterbodies or highly valued recreational waters. However, if we are to develop a strong national consensus on controlling toxics, data collection must be improved.

An integrated national monitoring and assessment program is needed to better understand the extent and impact of toxic pollutants in surface waters. The EPA's Environmental Monitoring and Assessment Program (EMAP) could provide such data. Of particular value are the indicators that EMAP uses to describe the overall condition of the ecosystem and the effects of stresses (such as toxicity) caused by pollutants (U.S. Environ. Prot. Agency, 1990). However, EMAP is designed to look at the health of ecosystems on a regional scale only, which may preclude detailed information from many specific waterbodies.

A program should produce more detailed information on toxic pollutants in surface waters. The U.S. Geological Survey's National Water Quality Assessment Program (NAWQA) is "designed to describe the status and trends in the quality of the Nation's ground- and surface-water resources and to provide a sound understanding of the natural and human factors that affect the quality of these resources" (U.S. Geo. Surv. 1988).

However, Federal agencies must make long-term commitments to these assessment programs if useful information is to result. Moreover, these programs appear to be proceeding independently of each other when they should be complementary so as not to duplicate effort.

Toxic Risks at Trace Levels

We also need to understand risks to human health and aquatic ecosystems posed by toxics in surface waters at trace levels. Analytical methods continue to improve as detectors become increasingly sensitive and preconcentration steps isolate extremely low levels of substances. EPA should sponsor the required research and development that will determine the environmental significance of these extremely low values. The presence of a substance at a fractional part per billion concentration in surface waters does not necessarily mean adverse impact. Yet concern naturally arises when low levels of toxics are detected with no information available to the public and regulators on potential or actual hazards. Detection accuracy and precision at these low levels are other problems.

We need to better understand the fate and effects of toxic chemicals, especially as they relate to exposure concerns that could adversely affect human health and biota. The Agency is beginning to address these questions, but much more laboratory and field data must be developed as the basis for deciding which toxics to control. When appropriate, industry should contribute information.

Site-specific Criteria

Discharge permit limits are increasingly being developed from water quality-based conditions that include stringent State toxic pollutant standards. These water quality standards are frequently the same as the section 304(a) criteria recommended by EPA because most States do not have the resources or the incentive to develop specific standards that differ from EPA's criteria. However, in many instances site-specific criteria could be developed by modifying the values in State standards for specific surface waters to reflect local ambient water conditions and resident aquatic species because sensitivity of these species may differ from the criteria basis and local water conditions can significantly affect toxicity or bioavailability.

While EPA has developed guidelines for deriving site-specific water quality criteria (U. S. Environ. Prot. Agency, 1984), the Agency has seldom encouraged their use by the States. As a result, few site-specific criteria have been developed. EPA and the States should be more supportive of this approach.

Development of such criteria would involve minimum agency resources since the discharger would have the burden to undertake laboratory and field studies needed to support a request for site-specific criteria. The problems have been the reluctance of regulators to consider site-specific approaches and the inadequate time available to develop proposals. Agency support should include granting variances when more time is needed to develop a technical case for site-specific criteria.

Measurable Permit Limits

State water quality standards and criteria are translated into discharge permit limits. The application of extremely stringent criteria, particularly for human health, often results in a calculated permit limit that is below the analytical detection limit for the method employed. Accepting such non-measurable limits can result in a serious problem for permittees who are not able to demonstrate compliance. In the latest draft of the Technical Support Document, the Agency recommends that, in such cases, the permit writer should use the method detection limit concentration as the permit limit, with a note in the permit that a monitoring result of "non-detected" be considered in compliance. An unmeasurable numerical limit in a permit serves no useful purpose and should be avoided.

In comments on the draft Technical Support Document (Chem. Manuf. Ass. 1990), the Chemical Manufacturers Association suggested one possible solution to this problem: an unmeasurable permit limit should be narrative and specify that no detectable amount be present. Also, the permit would reference the analytical method to be used to measure the pollutant and would specify the practical quantitation level as the reporting level.

This level would be determined by multiplying the matrix-specific method detection limit developed by using protocols published in Appendix B of 40 CFR 136 by a factor of 10. While I also have some concerns about this approach, it does recognize that permit limits should not be set below the practical quantitation level.

Watershed Management Approach

EPA should actively develop a watershed management approach for State water quality procedures to enable a comprehensive evaluation of total impacts from point and nonpoint sources of toxics in river basins, estuaries, or other natural aquatic ecosystems. Then wasteload allocations could be developed in conjunction with combined permitting for point sources and best management practices for nonpoint sources. This approach is used already by some States, most recently in North Carolina, where basin management plans are being developed.

Implementation for Bioavailable Metals

In addition, EPA should provide States with clear technical guidance compliance procedures for metals criteria that will define the bioavailable metal portion to be used as a basis for water quality criteria and discharge limits. The Agency has given only general guidance on the four analytical techniques (total, total recoverable, acid soluble, and dissolved metal measurements) that are acceptable for implementing water quality criteria (U.S. Environ. Prot. Agency, May 1990c). However, the National Pollutant Discharge Elimination System regulations specify that only total recoverable metal can be used to express effluent limitations.

Agency guidance is vague on how to translate from soluble and bioavailable metals concentration in the surface waters into total recoverable metals concentration in the discharge. Specific guidance should be provided to States since this is a major concern that both permit writers and permittees must address. In 1990, EPA began research on developing a technical basis for establishing a policy on metals criteria compliance. Hopefully, this effort is an EPA priority.

Risk-based Toxics Control

The validity of the mixing zone concept has been questioned. However, mixing zones remain a necessary interface between discharge points and ambient water conditions. Mixing zones for toxics should be allowed for discharges as long as the zone is limited and clearly defined on a site-specific basis to assure protection of the aquatic ecosystem. It is appropriate to allow mixing zones for all types of outfall configurations provided that each configuration can achieve adequate dispersion.

Numerical chronic criteria should be applied at the edge of the mixing zone. Allowing a zone of initial dilution as a small fraction of the mixing zone in which the acute criteria can be exceeded without causing adverse impacts on aquatic life is environmentally supportable. Mixing zones also should be allowed for bioconcentratable substances, with adequate safeguards to protect human health and the environment.

Priority Pollutant List

In the future, it would be more effective to solve water quality problems by using a scalpel instead of a shotgun. Therefore, EPA should develop a smaller and more focused list of toxics and use it as the basis for criteria development and source control instead of the broad spectrum 126-substance priority pollutant list. This list should be reworked since it includes substances of little concern today in surface waters and ignores known toxics of real environmental concern. Additional toxics that are serious problems to the environment and human health must be identified for control.

I strongly support a program that would identify these toxics in an approach similar to the method used in listing substances for water quality criteria development. EPA Administrator Bill Reilly has called for a risk-based approach to setting priorities in tune with the Science Advisory Board's proposals. I think this approach might provide a key management tool to focus Agency attention on the remaining truly serious toxics problems.

Antibacksliding

Another concern that EPA must address is antibacksliding. This provision makes it difficult for dischargers to accept permit limits based on water quality criteria that involve a limited database and correspondingly large safety factor. The scenario of concern is the following.

- The discharger installs costly treatment facilities to meet a tight water quality criterion based on little data and a large safety factor, only to have this criterion relaxed when additional toxicity results are included.
- However, the discharger is locked into continuing to meet the overly stringent limits because antibacksliding provisions do not allow relief.
- Therefore, dischargers may be unwilling to accept water quality-based limits other than those resulting from EPA-recommended criteria that already have a large toxicity database and are unlikely to change, which discourages development of new criteria.

The Agency should incorporate more flexibility into its guidance for implementation of section 402(o) antibacksliding rules for water quality-based permits. Industry would more readily accept limits based on water quality criteria developed from limited toxicity data if it knew that some relief would be possible if criteria are deemed too stringent. Also, the Agency should address this problem in positions it develops for reauthorization of the Clean Water Act.

Biological Measures of Toxicity

Whole effluent toxicity and other biological measures of toxicity, such as biocriteria, are additional approaches for viewing the potential toxic effects of effluents and the health of the aquatic ecosystem into which they discharge. However, whole effluent toxicity probably does not relate directly to in-stream effects in many instances because of the aquatic environment's complexity. Moreover, a single exceedance of a permit requirement should not be viewed as a violation. Biological variability is such that a single exceedance frequently is not significant nor can the cause be readily determined.

The permit writer should consider all the chemical and biological data for a specific discharge as well as the ambient waterbody conditions in an integrated approach to determine protective limits for the discharge. None of the three potential sources of information—chemical analysis, whole effluent toxicity, or in-stream biocriteria—should be evaluated alone in establishing water quality-based requirements.

Conclusion

To summarize, we need a comprehensive national database for toxics in surface waters and a better understanding of the risks to human health and the environment posed by toxics in trace levels and how they relate to exposure.

Industry must have a wider opportunity to use site-specific criteria to obtain measurable permit limits. EPA should develop guidance for a watershed management approach. The Agency should also develop an implementation policy for bioavailable metals based on sound science.

Industry believes that the mixing zone should remain an important concept in water quality-based permitting. EPA must develop a risk-based approach in setting priorities for control of toxic pollutants and should address problems in water quality-based permitting that result from antibacksliding prohibitions. Finally, EPA should use priority pollutant chemical analysis along with biological approaches such as whole effluent toxicity and biocriteria in an integrated approach that considers all data.

Adoption of such measures will enable both high quality waters and environmentally responsible industrial discharge activity.

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Toxic Pollutant Criteria—Toward a More Comprehensive Agenda

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Introduction

The Natural Resources Defense Council (NRDC) has been involved in the implementation of the water quality standards program for almost 20 years. We look forward to the development of water quality standards for the 21st century with a mixture of satisfaction and disappointment. Although substantial credit is due to State and U.S. Environmental Protection Agency (EPA) officials who have labored to implement the Federal Water Pollution Control (now Clean Water) Act's requirements since 1972, the promise of that law has been only partially fulfilled in many areas and unfulfilled in others.

The area of water quality standards for toxics is no exception. Criteria have been developed by EPA and adopted by some States for a number of toxic pollutants. New procedures have been developed to measure and control whole effluent toxicity. New techniques have been devised to detect toxics in smaller quantities and to measure acute and chronic toxicity and human health effects with greater precision. However, criteria exist for only a fraction of toxic and nonconventional pollutants—not even all of the so-called priority pollutants are covered. Even where some criteria exist, they often address only certain effects and ecosystems. Current criteria apply only in the water column and not in sediment or biota.

EPA Issuance of Water Quality Criteria

EPA's role in establishing water quality standards is specified in sections 303(c) and 304(a) of the Clean Water Act. Within one year after the act's enactment, EPA's administrator was required to develop, publish, and "from time to time thereafter revise," water quality criteria:

> *. . . accurately reflecting the latest scientific knowledge (A) on the kind and extent of* ***all identifiable effects on health and welfare*** *including, but not limited to, plankton, fish, shellfish, wildlife, plant life, shorelines, beaches, esthetics, and recreation which may be expected from the presence of pollutants* ***in any body of water, including ground water;*** *(B) on the* ***concentration and dispersal of pollutants, or their byproducts, through biological, physical, and chemical processes;*** *and (C) on the effects of pollutants on biological community diversity, productivity, and stability, including information on the factors affecting rates of eutrophication and rates of organic and inorganic sedimentation for varying types of receiving waters* [Clean Water Act §304(a)(1), 33 U.S.C. §1314(a)(1) (emphasis added)].

The three boldfaced portions warrant emphasis. First, criteria were supposed to address "all identifiable effects on health and welfare." Thus, criteria that address human health but not aquatic life, or cancer but not other human health effects, do not meet this mandate. Second, criteria were supposed to address "any body [all types] of water, including ground water." Criteria that address freshwater but not marine water, flowing water but not lakes or wetlands, or surface water but not groundwater, do not fully comply with the statute. Third, criteria were supposed to address "concentration and dispersal of pollutants, or their byproducts, through chemical, physical, and biological systems." Criteria that apply to the water column but fail to account for contamination of sediment, biota, or other systems, do not fully meet the statutory command. With respect to toxic pollutants, EPA's duty to promulgate water quality criteria was specified further in a Consent Decree filed in *NRDC, et al.* v. *Train*, 8 ERC 2120 (D.D.C. 1976), *modified*, 12 ERC 1833 (D.D.C. 1979). Paragraph 11 of the Consent Decree provides, in relevant part:

> *The Administrator shall publish, under Section 304(a) of the Act, water quality criteria accurately reflecting the latest scientific knowledge on the kind and extent of all identifiable effects on aquatic organisms and human health of each of the pollutants listed in Appendix A. Such water quality criteria shall state, inter alia, for each of the pollutants listed in Appendix A, the recommended maximum permissible concentrations* ***(including where appropriate zero)*** *consistent with the protection of aquatic organisms, human health and recreational activities* [12 ERC 1843 (as modified) (emphasis added)].

Of course, the pollutants listed in Appendix A to the Consent Decree define the list of toxic priority pollutants.

The following statement also deserves special focus. EPA expressly recognized that zero concentrations might be appropriate for some highly toxic pollutants based on water quality as opposed to technology-based factors. Of course, water quality standards are intended only to serve as a way station on the road to the Clean Water Act's ultimate zero discharge goal.

Pursuant to this paragraph of the NRDC Consent Decree, initial promulgation of water quality criteria for these priority toxics was to be completed by December 31, 1979. Almost 11 years after the revised deadline established in the Consent Decree, EPA has issued water quality criteria in some form for 109 priority pollutants. Thus, criteria are still lacking altogether for 17 of the priority pollutants. Moreover, these criteria are incomplete: they do not address "all identifiable effects on aquatic organisms and human health," for many more pollutants. Some address human health but not aquatic toxicity, freshwater but not marine toxicity, or acute but not chronic toxicity, or vice versa. Notably, not a single EPA criterion is set at zero.

More disturbing is EPA's pace filling these gaps. According to the *Gold Book* summary chart, only 12 new toxics criteria were published between 1980-86, when a large number of criteria were established to achieve partial compliance with the NRDC Consent Decree—a rate of just over two per year! (This estimate is actually charitable, as it counts multiple valence states of some metals, such as pentavalent and trivalent arsenic, as separate pollutants.)

Unfortunately, this simple numeric analysis does not tell the full picture, as EPA has defined the universe of its responsibilities far too narrowly. EPA must move beyond its current agenda in at least six ways with respect to water quality criteria for toxics. Each of these concepts is discussed in the following paragraphs.

■ **EPA must complete and move beyond the priority pollutants.** The list of priority pollutants served an extremely useful purpose in 1976; it focused EPA's resources on those pollutants that, based on information available at that time, were most critical to protecting human health and the environment. But 14 years have brought new chemical products and new wastes, additional ambient monitoring data, better effluent characterization data, and new information on the effects of various pollutants. A good example is the lack of water quality criteria for a wide range of toxic pesticides that are currently widely in use. Pesticides on the priority pollutant list focused on chemicals widely in use in or before the 1970s, some of which are no longer used.

■ **EPA must address the full range of human health and environmental effects. Until the Agency has done so, it must enforce its most sensitive criterion strictly.** Typically, EPA establishes its human health-based criteria based on the most sensitive human health or environmental end point. This approach would be acceptable under three conditions: if it is clear that the health or environmental effect that forms the basis of the criterion in fact represents the most sensitive end point; if these criteria represented mandatory minima (if States could only promulgate criteria at least as strict as the most sensitive EPA criteria); and if these criteria were always applied using a low flow estimate.

This is not always the case, however, as indicated by the recent controversy over 2,3,7,8-TCDD (dioxin). EPA's criteria document for dioxin recommends a criterion of zero to achieve complete protection, based on the assumption that dioxin is a nonthreshold carcinogen (U.S. Environ. Prot. Agency, 1984). But this recommendation is not taken seriously either by EPA or the States. Instead, EPA presents potential criteria to address lifetime cancer health risks of 10-5 to 10-7, ranging from 0.13 parts per quadrillion (ppq) (pg/L) to .0013 ppq (U.S. Environ. Prot. Agency, 1984). (These figures are for fish and water consumption.)

While the criteria document and other EPA documents present information on other human health effects of dioxin at slightly higher levels, no actual numeric criteria have been developed for human health end points such as reproductive toxicity and liver damage. Thus, when some States elected to promulgate dioxin criteria an order of magnitude weaker than EPA's 10-5 criterion, based only on a reanalysis of EPA's cancer risk assessment, they may have jumped over levels at which other health and environmental effects occur.

This problem is exacerbated by the fact that some States are using a measure of average streamflow (such as mean or harmonic mean), rather than an estimate of low flow such as 7Q10, to apply human health criteria designed to protect against lifetime cancer risk. This practice will result in in-stream concentrations that will be even higher during low flow periods and may pose other health risks, such as reproductive toxicity, that are based on short-term rather than lifetime exposure. For example, an ambient dioxin criteria of 1.2 ppq applied at mean flow will result in ambient levels in excess of 2 ppq under many flow regimes. EPA reports health effects as a result of reproductive toxicity at 2 ppq based on short-term exposure. So even if mean flow adequately addresses carcinogenicity, we may be putting our unborn children at risk by using this standard.

A similar situation exists with respect to aquatic toxicity. When EPA issued its dioxin criteria document in 1984, it had information showing that chronic aquatic toxicity occurred at less than .001 μg/L for rainbow trout: approximately 1,000 ppq. Based on this information, even Maryland's criterion of 1.2 ppq is well below the level at which aquatic toxicity is of concern, and EPA never issued recommended criteria to protect aquatic life.

But in its recent integrated risk assessment analysis of dioxins and furans from pulp and paper mills, EPA reported that an estimated chronic aquatic effects levels for 2,3,7,8-TCDD of 0.038 ppq (U.S. Environ. Prot. Agency, 1990a). (This figure was based on an observed effect level at 0.038 ng/L, with a factor of 1,000 to account for acute versus chronic exposure, differences in species' sensitivities, and differences in field versus laboratory effects. No safety factor was added.) This level is only slightly higher than EPA's recommended criterion to protect against cancer risk at the 10-6 cancer risk level, somewhat lower than EPA's 10-5 cancer risk level, and considerably lower than Maryland's 1.2 ppq criterion, which was based only on cancer risk with no consideration of aquatic toxicity.

One solution to this problem, of course, is for EPA simply to reject State water quality criteria weaker than EPA's recommended criterion based on its view as to the most sensitive human health risk. In approving Maryland's dioxin criterion, EPA obviously rejected this approach. Alternatively, EPA could impose on the State a heavy burden to demonstrate that, by second-guessing EPA's judgment with respect to carcinogenicity, it is not causing noncancer human health or environmental risks at levels between 0.013 ppq and 1.2 ppq. (NRDC believes this analysis is legally required by the Clean Water Act and 40 CFR § 131.11.) But EPA imposed no such burden on Maryland, whose dioxin submittal included no analysis whatsoever of noncancer health risks. However, to our knowledge, neither did submittals by other States. We discuss Maryland only because it was the first State to receive recent EPA approval of a dioxin criterion of 1.2 ppq.

The bottom line is that EPA is legally obligated to consider all identifiable human health effects and has not done so for many toxics, particularly those where criteria are based on risk assessment for nonthreshold carcinogens.

■ **EPA is required to revise criteria to reflect the latest scientific information.** Most of EPA's water quality criteria for toxics are now at least 10 years old. For many of these criteria, data on health and environmental effects may not have changed significantly; therefore, revisions are not needed. Clearly, however, this is not the case for some pollutants. Two examples—one specific and one generic—demonstrate this point.

For dioxin (focused on because of recent interest and regulatory activity), EPA's cancer risk analysis is based, in part, on an assumed bioconcentration factor of 5,000. Recent EPA evidence, however, reports bioconcentration factor levels for 2,3,7,8-TCDD more than an order of magnitude higher (U.S. Environ. Prot. Agency, 1990a). Clearly, EPA is required by section 304(a) to revise its dioxin criterion based on this new information (some of which was published in a peer-reviewed journal two years ago) (Mehrle et al. 1988).

A more far-reaching example is EPA's use of an assumed average human fish consumption rate of 6.5 grams per day for its risk assessments for all nonthreshold carcinogens. As a preliminary matter, NRDC believes that EPA is legally obligated to protect subpopulations that consume higher than average amounts of fish, such as recreational and subsistence fishers. Equally important, EPA's assumption is based on survey data that are more than 10 years old (U.S. Environ. Prot. Agency, 1990a). More recent data indicate significantly higher consumption rates, particularly by certain subpopulations (U.S. Environ. Prot. Agency, 1984). Section 304(a) requires EPA to revise its estimated human health risks based on these new data.

■ **EPA must address a wider range of waterbodies.** EPA has a long way to go in issuing water quality criteria that fully address acute and chronic toxicity in both freshwater and marine systems. However, inland rivers and the open ocean do not cover the full range of aquatic ecosystems, and special consideration must be given to toxicity in wetlands, estuaries, and lakes. Lakes and wetlands, for example, typically exhibit far longer retention times than flowing rivers and may demand stricter criteria on persistent toxics—in many cases, zero. This comment is made with some reservations, as flowing rivers simply transfer pollutants downstream to lakes, estuaries, and marine systems. Nevertheless, as shown by our experience with the Great Lakes, systems with high residence times can accumulate dangerous concentrations of toxics in water, sediment, and biota. The high productivity and different and varying temperatures and salinity conditions in estuaries similarly require special consideration when issuing water quality criteria. Finally, section 304(a) expressly mandates that EPA establish criteria for groundwater—obviously a significant gap in EPA's efforts to date under the Clean Water Act.

■ **EPA must move beyond water column criteria.** One of the most glaring omissions in EPA's water quality standards program is that, historically, it focused almost exclusively on water column concentration. This approach only partially takes into account the statutory command that EPA consider "the concentration and dispersal of pollutants, or their byproducts, through biological, physical, and chemical processes." This problem has been mitigated in part in recent years by EPA's promotion of whole effluent toxicity and its more recent and highly commendable move to supplement numeric water quality criteria and whole effluent toxicity with biological criteria.

By ignoring or partially ignoring such factors as contamination of sediment and biota, EPA's approach fails to protect against the full range of human health and environmental impacts of toxic pollutants. It also fails to move us sufficiently toward the Clean Water Act's ultimate zero discharge goal and the underlying objective of restoring and maintaining the chemical, physical, and biological integrity of the Nation's waters.

An exclusive focus on water column concentration assumes, for the most part, that toxic pollutants remain in the water column. Under this analysis, a municipal or industrial discharger of wastewater or runoff can discharge extremely large mass loadings of toxic pollutants so long as the concentration of the effluent is sufficiently low. This is problematic, particularly for large volume discharges and for discharges of runoff during high flow (and therefore high dilution) conditions.

However, all toxic pollutants do not remain in the water column; many toxics are sediment-bound rather than soluble and, over time, can accumulate in the sediment in dangerous amounts. Without the issuance of enforceable sediment quality criteria, which can be translated into stricter criteria-based effluent limitations and runoff controls, this problem will continue. EPA is working on the development of sediment quality criteria, but progress has been slow.

Similarly, pollutants in the water column can concentrate or accumulate in fish and other aquatic organisms. Theoretically, this factor is taken into account in the promulgation of ambient water column criteria. But as discussed in the context of the appropriate bioconcentration factor for dioxin, our understanding of bioaccumulation and bioconcentration is incomplete at best. Establishing criteria governing the presence of toxics in the biota themselves would provide an important second line of defense. If contamination of biota above the specified criteria occurs despite compliance with water column criteria, stricter permit limits can still be written (thereby better defining the limitations of the assumptions underlying the water column criteria), and the criteria can be revised accordingly.

Moreover, in writing water column criteria, bioconcentration and bioaccumulation are considered largely to address human health effects from consuming contaminated fish and shellfish. Omitted from the analysis are acute and chronic effects on wildlife, including not only fish and aquatic life but birds, mammals, and other species that consume contaminated aquatic life or are otherwise exposed to toxics in the aquatic environment.

Returning again to the dioxin example, EPA's integrated risk assessment noted that 2,3,7,8-TCDD in effluent from chlorine-bleaching pulp and paper mills "could be exerting significant adverse effects on aquatic life and on avian and mammalian predators feeding on aquatic life." Yet no numeric criteria have been issued to address these risks.

■ **EPA should pursue measures of whole toxicity more vigorously.** NRDC strongly supports EPA and State promotion and use of whole effluent toxicity to account for toxicity based on cumulative, synergistic, or other effects that are difficult to measure through numeric criteria alone. In fact, we believe that EPA should promulgate separate criteria for whole effluent toxicity under section 304(a).

Moreover, it is ironic that we are moving forward with techniques to address human health effects from cumulative or synergistic exposure to toxics in seafood and drinking water. EPA and

States should view this issue as an important challenge for the future.

State Adoption of Toxics Criteria

EPA performance alone does not result in environmental gains. States have the initial responsibility to adopt and to enforce water quality criteria for toxics. Only when States fail to perform this role must EPA step in.

Prior to the 1987 Water Quality Act, State performance in adopting water quality criteria for toxics was inconsistent and, overall, extremely sketchy. Few States had more than a handful of toxics criteria. As part of its beyond best available technology strategy for additional water quality-based toxics control, Congress in 1987 required all States to adopt numerical water quality criteria:

> . . . *for all [priority] toxic pollutants. . . for which [EPA] criteria have been published . . . the discharge or presence of which in the affected waters could reasonably be expected to interfere with those designated uses adopted by the State, as necessary to support such designated uses* [CWA section 303 (c)(2)(B), 33 U.S.C. § 1313(c)(2)(B)].

Of course, State responsibility to adopt water quality criteria for toxics does not end here. Even before 1987, States were under a general obligation to adopt all water quality criteria necessary to protect designated water uses and otherwise meet the goals and requirements of the Clean Water Act (CWA § 303(c); 40 CFR § 131.6, 131.11). Thus, the State duty to issue water quality criteria for toxics is limited neither to priority pollutants nor to the precise definition in section 303(c)(2)(B). The new provision only imposed a more specific requirement during a particular triennial review to dovetail with the 304(1) process.

Congress' 1987 directive represented a last chance for States to implement their responsibilities to establish water quality criteria for toxics. Nevertheless, State compliance with even the more limited agenda set forth in section 303(c)(2)(B) has been extremely poor. According to EPA's most recent analysis, only 15 States are in full compliance with that section and another 34 are in partial compliance (U.S. Environ. Prot. Agency, 1990b).

Of course, NRDC does not see eye-to-eye with EPA on what constitutes full compliance with this provision. According to EPA's October 1990 analysis, at least six States have adopted a translator mechanism, at least in part. While NRDC supports such procedures to supplement numeric criteria, we continue to believe that exclusive use of translator procedures violates Congress' express command that States must adopt numeric water quality criteria (Nat. Resour. Def. Counc. 1988). Notably, however, a large number of States adopted all available EPA criteria, taking advantage of EPA's years of research in developing them.

EPA has been quite patient with States that have been slow to comply with their statutory obligations. But EPA's patience is also constrained by law. Under section 303(c)(4) of the Clean Water Act, EPA now has a mandatory duty to promulgate water quality criteria for those States that fail to do so.

Streamlining the Criteria Process

Because primary responsibility for water quality standards has rested traditionally with the States, the concept of moving toward baseline national water quality standards has been considered controversial. But given the cost and complexity of developing defensible toxics criteria, it is time to reexamine this issue. Some States have been reluctant to cede their authority in this important area. Somewhat inconsistently, however, States often complain that they lack sufficient resources to perform all the Clean Water Act functions demanded of them.

NRDC believes that EPA water quality criteria promulgated under section 304(a) should be given the force and effect of law. This would give EPA water quality criteria the same status as EPA effluent guidelines issued under section 304(b). However, as with technology-based guidelines, States (or interstate entities) should not be preempted from promulgating additional criteria or those that are stricter than criteria issued by EPA. In fact, States would continue to be responsible for protecting water quality from pollutants not yet addressed by EPA. Obviously, such criteria would undergo the same formal notice and comment rulemaking procedure required of EPA criteria. This proposal would have the following related benefits, among others:

- **It would focus and conserve resources.** EPA devotes considerable resources to developing and issuing water quality criteria. Currently, States are required to duplicate these efforts in adopting their own criteria as formal regulations, even if they adopt standards based entirely on EPA guidance. These criteria then are subject to potential judicial challenge in every State, rather than when first issued by EPA. Moreover, 10 separate EPA offices then are required to review and approve water quality standards in every State, consuming yet more limited resources and promulgating EPA criteria when State criteria are inadequate. State and Federal resources saved by eliminating duplication of effort can be devoted to implementation and enforcement of water quality criteria. The significant number of States that opted for wholesale adoption of EPA criteria evidences some support for this notion.

■ **It would promote consistency and equity while preserving State flexibility where appropriate.** NRDC believes that serious questions of equity are raised when different States promulgate significantly different water quality criteria for toxics, particularly with regard to human health. While the sensitivity of aquatic species to pollutants varies, human sensitivities do not vary when considering whole State populations. It is fundamentally inequitable that citizens in some States should be exposed to risks of cancer or other health effects that are, in some cases, orders of magnitude higher than in other States. A fundamental tenet of the Clean Water Act is violated when States are encouraged to compete for industrial growth by weakening environmental standards.

Consistency is particularly desirable in such interstate waters as the Great Lakes and Chesapeake Bay. Currently, different criteria often apply across artificial political boundaries that bear no relationship to hydrologic or ecological realities.

Nevertheless, State flexibility is appropriate in some cases and should be preserved. States should be required to address toxics that are not covered by EPA criteria. Particular pollutants, such as pesticides used only for certain crops, may be a serious problem only in a few States, and therefore not high on EPA's list of priorities. However, relieving States of the obligation to promulgate criteria for more common pollutants addressed by EPA will allow them to concentrate resources on those toxics that are unique to, and perhaps more important to, their area.

In addition, States should be free to enact more stringent criteria where necessary to address particular conditions, such as more sensitive species or particularly high fish consumption levels. EPA criteria must be based on data from a range of species and must consider those that are pollutant-sensitive. However, it will not be possible for EPA to consider every possible species or environmental condition.

Conclusion

While considerable progress has been made since 1972 in developing water quality criteria for toxic pollutants, much more remains to be done. This can be accomplished best by eliminating duplication of effort between EPA and the States. EPA resources should be focused on completing water quality criteria for priority pollutants; addressing the full range of human health and environmental effects; revising criteria to reflect the latest scientific information; moving on to other common toxic pollutants, such as commonly used pesticides; developing criteria for the full range of waterbodies; and developing criteria to address contamination of sediment and biota. States should be freed of the burden of duplicating EPA efforts in issuing water quality criteria for toxics so that their resources can be concentrated on addressing local pollutants and conditions and on implementation and enforcement of water quality criteria.

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Questions, Answers, and Comments

Q. *(Randy Palachek—Texas Water Commission) I'm interested in the concept of applying human health criteria to small streams, or, as in our case sometimes, in midstream where pools still have an aquatic life use. Are there any flows, carrying capacities, or stream orders that you have evaluated of an appropriate level to apply these criteria?*

A. (John Howland) In Missouri, we classified for aquatic life protection those streams that have any type of permanent or semipermanent flow throughout the year. Streams that we have not classified or given the aquatic life designation are dry stream beds. We classified everything that has permanent pools and applied human health numbers to them. I'm not certain that this was appropriate because there probably aren't enough fish growing in some of these small streams to be of any health significance to people eating them. A lot of these streams don't get any angling whatsoever.

I was surprised that, during the water quality standards triennial review, we did not get any more opposition on that matter. We did get one suggestion from the regulated community, that we should allow for site-specific criteria development in those streams where there was no productive edible fishery so we would have a variance process.

C. (Mark Van Putten—National Wildlife Federation, Great Lakes Office) I would like to second Bob Adler's comments about the importance of the Act's technology base requirements, a particularly critical feature because technology based on effluent guidelines are probably one of the most immediate and best opportunities EPA has to implement pollution prevention.

My two comments both pertain to implementation of criteria. The first is the issue of whole effluent toxicity testing, which has been developed as a supplement to chemical-specific limitations. My concern is the use of effluent toxicity testing as an alternative to chemical-specific limitations. For instance, in the past, Michigan assumed additivity when developing effluent limitations for certain metals and, using that formula, put effluent limitations in the permit for each metal. However, the State has recently substituted an effluent toxicity testing requirement for those metals. We think that toxicity testing should be put in permits as an enforceable effluent limitation if it is going to substitute for chemical-specific limits, so if you violate the toxicity test, you violate the permit. It is not just give us information and, if we are having a toxic effect, we'll go back and put back in the limit.

My second point is on analytical limits of detection, where compliance monitoring is confused with environmental effects. We have a process, in place, with criteria to develop effluent limitations. Then we face a monitoring issue: how do we detect a violation? It's not appropriate to let the compliance monitoring question drive the application of criteria. There are different ways of monitoring compliance at the end of a process waste stream, using fish to bioaccumulate the pollutant. The uncertainty involved in analytical limits of detection should work toward minimizing pollution discharges. The discharger ought to worry that a new method will be developed during the pendency of the permit and therefore document violations to make every effort to achieve water quality base effluent limitations and not the safe harbor offered by analytical limiting detection. There is an environmental concern that nobody has data on: the accumulative effect of dioxin from each of the pulp mills having an adverse impact on Lake Superior or Lake Michigan. This is a very important point and one of the many examples of how important the application of criteria is in technical support documents.

C. It's a real dilemma that is tied to the fact that we have more and more main criteria set to such low levels. What we have to recognize is that a permittee is liable for that permit. Every violation can put a permittee into a situation where an action can be brought by the agency. At Du Pont, we adopt the position that we really want to know whether we can be in compliance with that discharge permit. We want to have methods that we can tie compliance to, so we know whether we are indeed meeting requirements to discharge an effluent and are in compliance with the permit limit. This sort of a problem has not been resolved yet, and it's becoming more and more of a concern to us—and also to permit writers in many of the States. It's something that has to be looked at from a practical point of view, yet at the same time, I recognize that assurances have to be made that the discharge will not adversely impact the environment.

C. Water quality is not supposed to be limited by achieved ability or economics but technology, which forces it to meet limits. I would argue that of monitoring compliance with the limits, so I would not advocate raising the water quality base on effluent limits to the current level of measurability.

As to enforcement, obviously you can't bring an action against someone if you can't prove that they are in violation. If the detection limits are not sufficient to measure that low, the discharger is not liable for prosecution. You've got to prove the violation.

C. (John Howland) Mark's first point was on toxicity testing or the chemical-specific criteria. I would like to go back to that three-legged stool. I agree that biocriteria, toxicity testing, and chemical permit limits are all necessary, I just happen to be a little bit more comfortable putting all my weight on one of those legs right now rather than the other two with the experience we have, but certainly it gives you prosecutorial discretion to use any one of those three if you need to go after a discharger.

Q. *Two of the speakers discussed the concept of a mixing zone in the context of application to chemicals that bioaccumulate in the food chain. I imagine there is some logic to the concept of a mixing zone though I've never explored it, but I've had trouble understanding how it can possibly be applied to compounds that bioaccumulate.*

A. I am not implying that a mixing is appropriate every time. There are, no doubt, some chemicals for which a mixing zone is not appropriate. Mixing has to be determined by looking at what happens to that chemical in the environment, and if we come to a conclusion based on available information that that chemical is accumulating in the food chain in concentrations, then the decision may well be made that a mixing zone is not appropriate for that particular chemical.

C. I'm not in a good position to answer because I do not believe in mixing zones. The focus of your question could have been broader, but if you believe in mixing zones or not, EPA water quality standards advise against mixing zones for bioaccumulative or persistent chemicals.

Q. *As I understood Mr. Schwer, he was advocating mixing zones for some bioconcentrative substances with precaution. What kind of precaution can one take and still have a mixing zone for a bioconcentrative chemical?*

A. (Richard Schwer) Precaution means to look at the fate and effects of a particular chemical to assure that it's not getting into our food chain and creating a potential adverse impact on human health or biota.

Q. *Would you advocate this for very specific types of water systems?*

A. (Schwer) I'm advocating that you take a look at the type of ecosystem and the possibility for bioaccumulation to a point where you have adverse impacts.

Q. *(Don Armstrong—Pima County, Arizona) Mr. Adler, I understand your point, but science tells us that a number needs to go down and we have to be able to incorporate that. How about when science tells us that further testing says the number is too low at this point? Are you as willing for us to move the level up?*

A. (Robert Adler) Yes. I believe that good science ought to be applied in writing water quality standards.

Q. *(Mary Kelly—Austin, Texas) Please comment on the legality of site-specific variances for water quality standards that are not subject to EPA approval, as part of setting that type of specific standards. (If the site-specific standards are set during a permit process that is not subject to EPA approval, is that water quality standard legal under the Clean Water Act?)*

A. I would say yes if the water quality standards regulations allow for setting those site-specific water quality standards, providing that EPA procedures are followed.

The ones that I know of are approved through the regional office. I think we should distinguish between site-specific water quality standards, which are legal if they protect the designated use in the actual or potential use of the water and meet the other requirements of the Water Quality Act. Your question went more to variances from water quality standards, which we have accepted as appropriate in the context of variances from water quality-based effluent limitations, not variances from water quality standards.

Q. *(Kevin Brubaker—Save the Bay) I was struck by Mr. Adler's comment that water quality standards should be used merely as a stepping-stone to zero discharge. All three commentators suggested that we needed more research to promulgate more water quality standards. With 60,000 chemicals being produced right now and a short-term goal of creating standards for 126, I'm wondering whether the speakers can respond on how far they think we can get by continuing to promulgate chemical-specific standards?*

A. I believe that technology-based standards ought to drive pollution prevention. Water quality standards play a critical role in that process; you might have a set of effluent guidelines for an industry, five percent of which might be subject to stricter effluent limitations if based on water quality standards. When EPA revises the effluent guidelines (as it is required to do under the statute), it has to find a new level of BAT, so a lot of water quality standards can play a fundamental role in driving pollution prevention as well.

C. I'm pessimistic that we'll continue to look for criteria for new materials. I believe we are manufacturing these materials so quickly that we'll always be a step behind the ones that really need the criteria. I don't see how we'll ever catch up.

C. We are giving short shrift to the other regulatory programs, such as TSCA and FIFRA, that are specifically designed to make sure that new chemicals coming out into the market are checked in an effort to head off environmental problems. In the past, we suddenly discovered that DDT or some other chemical had created environmental problems. You have to take a holistic approach toward trying to evaluate potential impacts, particularly from new chemicals, and not just rely on water quality standards.

C. (Adler) We are trying to make the new set of requirements similar to our requirements for the water quality criteria. I think that would help fill up the gaps.

Q. *(Steve Pawlowski—Arizona Department of Environmental Quality) Mr. Adler, you mentioned that you felt that the water quality standards should be technology-forcing. Could the panel comment on what role (if any) economic analysis or technology feasibility has in the development of water quality standards for toxic pollutants? Is there a rule for that type of analysis in criteria development, or should criteria simply be based on what is necessary to protect human health and aquatic life?*

A. (Adler) Legally, economics are not supposed to play a role in writing water quality standards or determining their achievability—with two very narrow exceptions in the EPA regulations. One is the use attainability, part of the use attainability analysis in Part 131. And the second is to determine variances from water quality-based effluent limitations.

C. I think I disagree with Bob (Adler) on the answer he gave to one question. The question was: If new science demonstrates that water quality standards can be relaxed, are you prepared to follow the good science? And I took Bob's answer to be yes, but I think my answer would be no. If we have effluent limits in place based on the previous standards or other control requirements (BMPs), I'm not prepared to follow the good science because scientists can only argue about how much pollution is too much and we will create incentives for consultants, permittees, and other regulated parties to demonstrate that the Kalamzoo River really has a little more assimilative capacity for this and that toxic than we thought last time and, therefore, the water quality standards-based effluent limitations ought to be relaxed. There is a rationality to antibacksliding, and it is that if we have treatment capacity in place, whether it's put there to meet water quality-based or technology-based limits, we ought to keep operating that treatment and get additional benefits. Water quality standards are the minimum, not the maximum. They are not the desired condition—zero discharge is. Antibacksliding is the key element to move towards zero discharge, to force technology and keep the scientific arguments about new criteria for new pollutants from becoming arguments about whether we are regulating too stringently for a given pollutant and a given stream.

Finally, on the LOD limited detection discussion; there is one party that we are forgetting. The discussion has been in terms of State enforcement and that an agency won't enforce if it can't prove there are violations. But the Clean Water Act gives independent enforcement rights to citizens like all of us here and also groups like the one I represent. When a State agency or EPA puts an LOD safe harbor in a permit, they are cutting off my enforcement rights as well as saying up front that they are choosing not to enforce. If a citizens' group or an environmental organization wants to be crazy enough to take some contaminated fish data downstream, go in the Federal court, and argue to a judge that a permit violation is occurring, I think that they ought to have that option and the agencies not be precluded with that safe harbor.

C. (Richard Schwer) First of all, I think our major concern regarding antibacksliding is criteria that have been developed with an extremely limited database because of concerns about what you are protecting with that criteria and the time and money (lots of money sometimes) to develop criteria based on really broad databases. In cases like that, there ought to be some opportunity to relax the criteria if they are appropriately based on a broader database that is more representative.

The second point regards treatment facilities that are in place already. It is expensive to operate those treatment facilities, particularly when you're talking about advance treatment; so, it is a tremendous burden to continue to operate that treatment facility, using the appropriate chemicals and monitoring to an extremely low level. If that's really not necessary to protect water quality, it should be taken into consideration, too, because that's part of the whole equation.

Q. *(Mike Kadlec—Mohawk Tribe) I agree with Mr. Adler's speech that technology should be a motivating factor for criteria. What would be the motivating force for technology to increase, thus increasing the quality of the criteria?*

A. I'm not sure I understand the question. There are two motivating factors for driving technology. First, if you are a discharger and you are not doing as well as the rest of the industry, then the technology-based standard will force you to come up to par. Second, if a certain subsection of the industry is required to do better based on water quality standards and comes up with better technology, then EPA should apply that across the board by rewriting the technology in their standards.

Q. *But won't it be a disadvantage for industries to put money into advancing technology when it already applies to criteria set out by EPA?*

A. If you apply a stricter water quality-based criteria, you are forced to come up with a better technology or to spend more money.

Q. *So what you are saying is EPA should always have criteria that are slightly better than the technology at the time?*

A. Technology-based criteria are defined as the highest achievable technology according to various statutory criteria for the industry, but a water quality-based limit can go stricter and will then force technology to move forward.

C. In response to Mark Van Putten's statement on antibacksliding from a State agency perspective, it seems to me that policy developed in the mid-1970s had a logical basis as applied to the technology based permit limit. If a discharger was already able to meet a certain level, then that had something to do with requiring that discharger to meet levels that were supposed to be based on technological achievability.

That same logical relationship does not exist with respect to water quality standards-based permit limits. I am concerned that, if antibacksliding is pushed too hard from the water quality standards standpoint, it will have negative environmental consequences. It makes State agencies hesitate to act on the best current information, which tends to be not very complete in many cases; they hesitate to adopt stringent standards because if they've made a mistake, it's too late, they can't ever change them effectively. We are much better off if we rely on the best current science and adopt stringent standards in the face of uncertainty when that's appropriate. If we get better information later on, we should be willing to abide by it with respect to water quality standards, now that technology-based limits are a separate issue.

C. I have two responses to that. One is that Congress expressly adopted an antibacksliding provision in the 1987 act, so it certainly can't be true that antibacksliding is a concept of the past—at least Congress didn't think so. But there are exceptions to antibacksliding, including exceptions for mistakes in factual or other information, so I think the point is overstated.

A. *(Larry Shephard—U.S. EPA Region V, Chicago) Would the speaker suggest that maybe the direction we should be taking is national water quality standards? Bruce Baker made several comments that maybe all the States would be willing to give up some flexibility to address the problems. What do people see as arguments for supporting or opposing national water quality standards?*

A. There would be a problem with the regional characteristics of water (for example, where you have high selenium in Wyoming), but I am all for it. If EPA can develop national numbers, put them in place in all 50 states, and add some regional specificity to them, that would be fine with Missouri.

A. I'm not sure how I'll come down on national water quality standards. I can see some pluses in terms of both industry and the States; however, I can also see some negatives. My big concern would be requiring specific criteria that aren't appropriate in certain sections of the country and may result in the need for a lot more variances or emphasis on site-specific water quality criteria to develop relief from the national numbers.

A. I understand that about 35 states have accepted the national water quality criteria. There are interstate standards but very little variation.

A. Generally, nationalization of water quality standards could be worse than nationalization in eastern Europe. It should be a last resort when all else fails.

C. When the Great Lakes governors worked out their toxic control strategy, one of the issues that came up was whether to use a lowest common denominator. Everybody agrees that identical standards could weaken some, and, if such a thing happens, that States can have stronger requirements.

C. (Bob Adler) EPA is supposed to look at a reasonable range of sensitive species in coming up with criteria. That is supposed to be conservative, supposed to apply with a margin of safety, but we ought to have presentably applicable Federal water quality standards without preventing the right of States to promulgate stricter criteria if they think they can justify them.

C. (Lee Dunbar—State of Connecticut) If you look at the various States, you'll find that most have criteria that are very close, and many have adopted identical numbers. However, if you were to operate a manufacturing facility in each of those individual States, you would find a wide range of permit conditions, a wide range of limits, and wide range of treatment requirements from State to State because the mixing zone policy is how much pollution is allowed. The water quality permitting program has evolved from a State-by-State issue back in the Reagan years, where everybody was told "Here is the objective, States, figure out if there's a way to do it." So we wound up with a lot of different programs with not much consistency. Each State is trying to take advantage of the strong point in their resources to develop the most effective program, and standards are just one part of an integrated water quality program. If you were to implement across-the-board numbers, you would reap the same havoc because of other policies that had to key into them. You can't just change one aspect of the program. There are some serious issues that we should be paying attention to and none of us should forget what we are really trying to do: we are trying to protect water quality. Sometimes we get a little bit too fine, and the work is not getting done on time.

C. On the national applicability of standards, when I made my statement that Missouri would favor that, I was speaking from the standpoint of a program manager. If all the States have the same numbers in the same implementation policies, there would be no quibbling: everybody would have the same groundwork, the same rules to go by, and it would allow me as the program manager to deal with those real issues.

C. My concern would come when the rubber meets the road, when the permittee decides what to accept in the proposed permit and what to try to appeal. If the permittee is faced with national standards that have been mandated across the country, I think he may justifiably question whether these particular criteria are really applicable in that body of water for that particular region. National standards may not make the water quality section job and the permits section job any easier; in fact, they may make both more difficult.

A. *Maryland is one of the States that has opted for the EPA criteria, and we are currently being legislated. As a followup to the previous speaker's question, we come from different States and have found that, generally, most of the States had indeed adopted EPA criteria, but when we try to get more information about implementation policies and procedures, we weren't so successful. We were told by some of our industries that neighboring States had different permit limits. My question is to EPA: I find that although standards are EPA-approved, there generally isn't a formal approval of implementation policy and procedures. Is that going to occur in the future? Will information be available from EPA as States that have adopted water quality criteria translate standards into permits?*

A. (Nelson Thomas) I know available information is being updated in the technical support document that gives general guidance on implementing criteria; but, as far as summarizing how States have put it together, only the actual criteria that have been developed have been summarized.

A. (Bill Diamond) Nelson is right as to the source of guidance and information we put out. When EPA regions review the water quality standards program, they not only look at criteria and numbers but also implementation procedures. It's an evolving situation. Recently in Maryland, for instance, we disapproved a water quality standards program because implementation procedures were not acceptable. In Maryland, we were concerned about an antidegradation policy and a mixing zone.

In terms of guidance that comes out, there is flexibility. Implementation procedures come out under the Clean Water Act just as often as numerical criteria. That's why you have the disparity, and we do not have a summary on each aspect of those implementation procedures.

The question was, is that something that will be developed? Over the last couple of years, we will be doing audits on particular aspects of a program. A couple of years ago, we did audits of all State antidegradation procedures with a report that was state- and region-specific and sent back followup information that we wanted to address in the next final review. We have just completed an assessment of variances across all the States, and we are doing the same thing as far as sending information back to our regions.

C. (Bob Campaigne—The Upjohn Co.) We are beginning to get to the real issue. We have adopted, by science, some numbers that cannot be met. States are being forced to implement those numbers and then are playing games in order not to end up with permit conditions that shut the whole society down. I'm not talking about chemical plants, I'm talking about residential parking lots and apartment buildings that discharge pollution in excess of scientifically derived water quality standards.

We as a society do not have the technology (not even close to it) to meet Hartford quadrillion limits of many of these compounds. I think that's the crux of the matter. The States are adopting a standard based on EPA guidance and trying to find some mechanism so they can live with it, and that mechanism is a way to try to get around that standard. We have to face up to that and try to deal with it.

C. (Bob Adler) There are more variance mechanism loopholes in the exceptions in the Clean Water Act and Regulations than I can certainly keep track of, and more than ample room for flexibility when an adequate case can be made that a limit cannot be met. But I've heard for many years about what can and can't be met. In Alaska where I used to work, our expert witness argued to EPA in 1975 that total cycling for placer mining effluent was possible. It took us some six to eight years of administrative adjudication before EPA knew where we stood and finally promulgated a national effluent guideline for placer mining. And guess what? Total recycling was the chosen technology for most mines. So where there's a will, there's a way; if you keep pushing, you'll force technology to meet the limits.

Q. *(John Jackson) Bob Adler, you made a comment about the water quality base forcing technology to occur. Could you comment on the time period between when water quality-based standards are set and the technology is updated to meet them. What do you do in the interim?*

A. (Bob Adler) That takes us to the decision about whether or not you will give a schedule for compliance with water quality-based standards. I wish I could give you the Natural Resources Defense Council's view of that, but the decision and the implications are fairly new and, to be quite honest, we are discussing whether it is preferable to allow a compliance schedule for water quality-based standards limits or to make that mandatory requirement immediately, which would encourage States either to weaken water quality standards or to write a compliance schedule into their regulations. I'm not yet sure where we come down on this.

Q. *(Robin Garibay—The Advent Group) You gave a specific example of a way to modify water quality standards—dry technology—and I'll give you another: where you have specific mercury in water quality standards and there is no technology to remove mercury from, say, a municipal ethlyn discharge, so a permit holder would be required to follow a variance procedure. Instead, why not take that water quality standard back before promulgating it and take into account that there is no technology to achieve a nondetected mercury, particularly in municipal and industrial efforts?*

Q. *(Adler) Is this a POTW that's meeting a mercury limit?*

A. (Robin Garibay) For example, there are also going to be industrial dischargers that will have nondetector mercury limits. Mercury is there, basically coming into the participating POTW, so it may come in at a level of 2 to 3 parts per billion but there is no technology to take 2 to 3 parts per billion wastewater down to nondetect.

A. (Adler) I guess a definition of industrial use of that material would depend a lot on the source.

There is a difference (in my mind) between national background and background that is caused by nonpoint source runoffs—sources of industrial pollution that are supposed to be taken into account as part of the wasteload allocations process in Parts 130 and 131 of the regulations. We could probably have a whole panel discussion on how to implement wasteload allocations, taking into account depositions and background sources.

SEDIMENT MANAGEMENT STRATEGY

A Strategy for Sediment

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Introduction

Over the past 10 years, quite a bit of sediment data has been collected in New York State to support proposals for dredging, areas of concern in the Great Lakes, water-related construction projects, and inactive hazardous waste sites. In general, either through program requirements or growing initiatives to pursue possible sediment contaminant problems, there is a high frequency of projects with data available at early stages of review. However, most data offered are bulk sediment analyses of metals and persistent organics. When biological testing is done, it is usually for acute toxicity. These kinds of data are often found wanting when perceived use impairments are being explained.

Where sediments receive pollutants from urban areas or what might be described as "conventional industry," more attention must be paid to the less exotic chemicals (such as monoaromatics, chlorobenzenes, petroleum, and chlorinated solvents), which are discharged in runoff as nonpoint source pollutants in much greater amounts than the exotics (such as PCBs, dioxins and furans, and organochlorine pesticides). In addition, there should be much more chronic toxicity testing of sediments. Of course, to do this, we must support development of standard chronic or early life stage tests and follow-up validation. An array of chronic or early life stage sediment toxicity tests are available, but the best should be selected, tested, and promoted, as the seven-day fathead minnow and *Ceriodaphnia* water column tests were six years ago.

Natural Recovery

Contaminated sediments can undergo a natural recovery (or self-cleansing), a perfectly viable option to select in certain situations. In New York State, the Divisions of Fish and Wildlife and Marine Resources recommend conducting a fate assessment for pollutants found in sediments in excess of State sediment criteria guidance. Included in the guidelines are a number of nonpersistent organics, including the haloalkane and haloalkene solvents that are often found in sediments adjacent to hazardous waste sites. The divisions recommend that a determination be made of the time it will take to achieve a natural recovery to acceptable levels, and if that time is found to be acceptable, then sediment remediation may not be necessary. Of course, the source of the sediment contamination would have to be eliminated. Perhaps the most useful part of this regulatory exercise when dealing with nonpersistent organics is obtaining a guarantee of source elimination because even with chemicals that rapidly degrade, unacceptable levels can remain indefinitely in sediments with an ongoing source.

For persistent organics and metals that are causing use impairments, evaluation of the natural recovery alternative is considerably more problematic. If sources of these pollutants are eliminated, most environmental fate models predict a decline over time of the bioavailable amount of pollutants in sediments. This natural recovery may be an acceptable remedial alternative if several conditions are met:

- Reduction of the amounts of bioavailable contaminants in the sediments should not be a result of contaminants being washed downstream and simply diluted throughout the system;
- Recovery once achieved must be expected to be permanent and cannot be stirred up again by predictable high flows, storms, or human activity; and
- Time to recovery must be "acceptable." Is 20 years an "acceptable" time to wait for contaminants such as PCB or dioxin to be buried by sedimentation and result in reductions of fish flesh residues to safe levels?

Permanent versus Temporary Solutions

Most proposed solutions are generally temporary. However, there are some areas (at least in New York State) where sediment contamination is so great (for example, in percent levels of persistent organics) that fixation and/or containment either in-place or off-site is probably not the most sensible solution. In these situations, a permanent solution would be best.

Some permanent solutions are available that hold promise for immediate use. For example, hazardous waste incinerators that are run at maximum efficiency and with all available emission controls can achieve high destruction and low toxic pollutant emission levels. Where incineration is proposed, risk to humans and natural resources from emissions should be fully assessed and a determination made as to acceptability of the emissions. How to make that determination is another story.

National Sediment Criteria Funding

It is easy to imagine a scenario in which national sediment criteria are adopted and programs implemented to ensure that clean sediments do not exceed criteria and to require that contaminated sediments are cleaned up, to some extent. Full Federal funding would make such a program easy to bear. However, it is probably safer to assume that funding would involve some sort of a Federal/State/local cost-share program.

In the Northeast where, in 1991, recession is quite deep, States and local governments would probably have great difficulty in coming up with funding. Industry's ability to pay for any responsibilities mandated by a new sediment quality program may also vary greatly.

Given these limited resources, what should States do? One way to get more for our dollars is to bypass some of the costly sediment assessment work in certain situations. For example, where there are ongoing loads from either point or nonpoint sources of nonpersistent pollutants that are known to contaminate sediments, States can cut right to developing control and prevention programs. EPA should take the lead for making the generic case that any discharge of such pollutants causes sediment contamination and waterbody use impairments and that prevention and control programs are necessary and should be implemented immediately. These should be adequate measures to take since many nonpersistents will respond to "natural recovery."

There are some other funding and resource implications when it comes to remediation of contaminated sediments. Through the Federal Superfund, and in New York State, the State superfund, some contaminated sediments will be cleaned up. Presumably these programs will not clean up all contaminated sediments but will deal only with those considered most polluted. Once we remediate the most contaminated sediments, perhaps we should consider cleaning up only those that cause some significant threat or whose costs from use impairments outweigh remedial costs. In other words, we should be judicious when expending public funds for remedial activities.

Where private parties are found responsible for sediment contamination, we should still be careful when requiring remediation expenditures. When remediation is not considered feasible, possible, or cost effective, an additional course can be followed: damage claims can be pursued to compensate for lost use of resources as a result of sediment contamination caused by private parties.

Conclusion

At least one theme seems to emerge from the Sediment Management Strategy panel: sediment criteria will probably indicate that many or most sediments are contaminated. Sediment management strategies must prioritize sediments for cleanup and help determine how many get cleaned up and the consequences that may result from those that are not remediated.

Sediment Standards Development in Washington State

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Introduction

Washington is one of the first States to adopt official standards for regulating the concentration of toxic chemicals allowed in underwater sediments.

Less than three years ago, the Puget Sound Water Quality Authority directed the State Department of Ecology to develop sediment standards that could be used to regulate sources of sediment pollution and prioritize existing problem areas. Hard work by the Department of Ecology and consultants resulted in the 120-page regulation (WAC 173-204), adopted March 1991, that will be administered through the Federal National Pollutant Discharge Elimination System (NPDES) permits that the Department of Ecology issues to industrial and municipal dischargers.

Currently, these standards will be applied only to marine sediments in the Puget Sound region because site-specific data were used to generate the values. Specific values will be added for freshwater and other marine sediments as these criteria are developed.

A unique feature of the proposed regulation is that it defines both a "no adverse effects" level and an acceptable "minor adverse effects" level that are used to guide sediment management decisions regarding source control and cleanup. The no effects level, the recommended goal set for all sediments, is defined as the official sediment quality standard.

A maximum minor effects level is used to set an upper limit for conditions that are allowed to exist in sediment impact zones established as part of source control standards. Sediments that exceed this level are required to undergo a remedial investigation as defined by the sediment cleanup standards.

Representatives from numerous regulated discharge sources participated in sediment advisory committees and endorsed the idea of prioritizing sediment cleanup efforts and allowing sediment impact zones. However, the regulated members of these advisory groups believe that Washington's Department of Ecology is moving too fast to adopt sediment standards without proper verification of proposed methods.

This presentation provides an overview of the new regulation and recommends areas for research.

Sediment Contamination in Puget Sound

Sediment contamination in the Puget Sound region has been partially assessed by numerous surveys that measured sediment chemistry values and performed biological sediment tests. Results of these studies showed that problem areas are primarily located in embayments near urban industrial centers. Several areas within Puget Sound that have been designated U.S. Environmental Protection Agency (EPA) Superfund sites are in various stages of investigation and potential remediation.

Results of two previous activities played a major role in the approach Washington's Department of Ecology selected to develop sediment standards. Studies at the Superfund site in Commencement Bay resulted in the development of the apparent effects threshold (AET) approach for deriving numeric chemical values that would be expected to produce a detrimental biological response. The AET approach was then employed in the Puget Sound Dredge Disposal Analysis to develop a regulatory framework for determining suitability of dredge material for open water disposal. Extensive public review and acceptance of this process, along with biological testing methods, served as guides for developing sediment management standards.

New Sediment Management Standards

The proposed regulation includes three separate standards for managing the quality of sediments:

- Sediment quality standards,
- Source control standards, and
- Sediment cleanup standards.

Each is defined by a list of numeric chemical values and specific biological testing responses.

These sediment quality standards define conditions that would be considered acceptable anywhere in Puget Sound. They are based on the desired goal: that no adverse effects should occur to biological resources or to human health. Currently, the regulation defines only no effects criteria for environmental protection; human health criteria have not been established. No effects criteria for environmental protection are the same whether specified by numeric chemical values or biological testing, as illustrated in Figure 1.

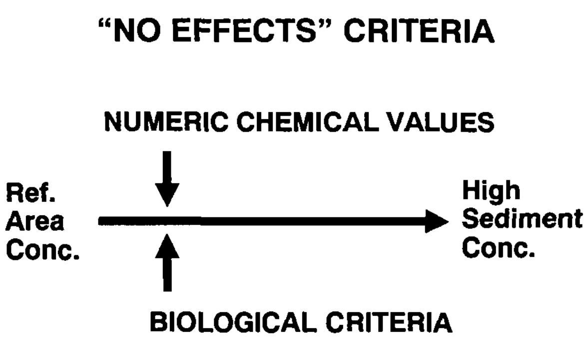

Figure 1.—Numerical chemical values and biological tests are used to define a no effects level set as the sediment standards goal. The horizontal arrow represents the level of sediment contamination increasing from reference area concentrations to high level sediment concentrations.

The AET Approach

The AET approach was chosen by Washington's Department of Ecology as the method for deriving numeric chemical values for environmental protection. The lowest AET value for four biological tests was used to derive no effects values for 47 chemicals, including eight metals and 39 organics. Sediment concentrations must pass all 47 numeric criteria to comply with the no effects sediment standard. The Department of Ecology prefers to use the AET approach because it is based on local data and allows definition of a large number of chemical criteria. The disadvantages of AET are that the values are not true cause and effect values, nor do they define a specific level of environmental protection.

The AET approach is only one of several methods that can be used to define numeric chemical criteria, as indicated by the listing in Table 1. A different approach, equilibrium partitioning, is being used by EPA headquarters to develop national sediment standards. There are potential problems in the fact that Washington State's and EPA's national programs use different approaches to establishing sediment standards. Moreover, all of the regulated discharge source representatives participating on the two sediment standards advisory committees have unanimously opposed using the AET approach because the values are not based on demonstrated cause and effects.

Table 1.—*Five approaches for developing numeric chemical criteria for environmental protection.*

- Apparent effects threshold (AET)
- Equilibrium partitioning (EP)
- Screening level (SL)
- Spiked sediment bioassay (SSB)
- Reference area concentration

Biological Testing

Biological testing can confirm or overrule the sediment quality classification established by using numeric chemical criteria. A specified protocol requires three separate biological tests: two acute and one chronic. The no effects criteria is met only if all three biological tests pass. If only one biological test fails, then the sample is considered a minor effect and could be allowed in a sediment impact zone, as shown in Figure 2. If more than one biological test fails, the sample would exceed the minor effects level, which would indicate that a sediment cleanup evaluation is required.

The concept of minor effects is a critical factor in successfully implementing sediment standards. This approach assumes some level of minor effect that is acceptable for a period of time while other higher priority sediments are addressed. Figure 2 illustrates how the two criteria levels relate to increasing sediment concentration and different

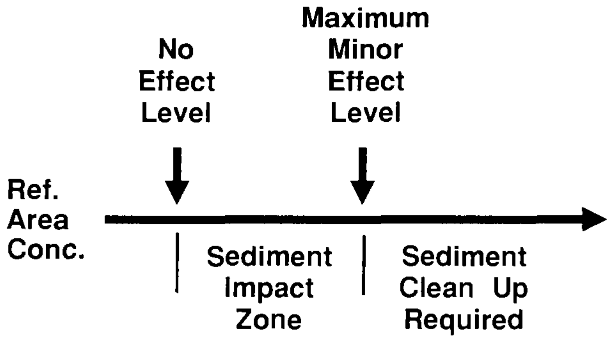

Figure 2.—Sediment management options are increased by establishing both a no effects level and an acceptable minor effects level. This approach allows the large task of sediment clean up to be prioritized in a logical and workable manner.

management options. Even if a perfect no effects level can be defined for all chemicals, the values will be so low that large geographic areas of sediment will exceed these standards.

Since it is impractical to clean up all these sediments simultaneously, concentrations must be prioritized into ones that must be cleaned up and ones that can be managed in place. Sediment concentrations between the no effects and maximum minor effects levels would be eligible for a sediment impact zone, while sediments above these levels would be required to be cleaned up.

Sediment Impact Zones

Sediment impact zones are administered as part of the sediment source control standards designed to limit discharge loading so that all sediments eventually achieve standards. This approach provides a way to regulate sediments that exceed the no effects level but where concentrations are not high enough to warrant immediate cleanup.

An acceptable size for a sediment impact zone is predicted by using mathematical dispersion models. The overall goal is to keep the area of influence as small as possible and, eventually, eliminate it. Eligibility for obtaining a sediment impact zone is limited to discharges that receive all known, available, and reasonable treatment (AKART). Substantial monitoring is necessary to comply with specific sediment impact zone size requirements included in the Federal NPDES permit.

Maximum conditions allowed in a sediment impact zone are set at the maximum minor effects level. Biological testing protocols define this level as allowing no more than one of three biological tests (two acute and one chronic) to fail. Corresponding chemical criteria were derived by selecting the maximum concentration that would allow only one of the AET biological tests to fail. Numeric criteria values listed for maximum minor effects are generally higher than values listed for no effects levels. However, correlations in the AET database resulted in 10 of the 47 compounds having identical values for both standards.

All the representatives of regulated discharge sources supported the idea of prioritizing sediment cleanup efforts and allowing lower priority sediments to be regulated by monitoring in-place sediments. However, they are concerned that the modeling approach used to define sediment impact zones might be too complicated and therefore want the methods validated before adoption.

The Department of Ecology plans to use two EPA mathematical models (CORMIX and WASP4), which may lack the required accuracy for defining sediment impact zones.

Sediment Cleanup Standards

Sediment cleanup standards define the maximum sediment concentration allowed before triggering a mandated requirement to perform both a sediment cleanup evaluation and a sediment cleanup action. These same trigger values define the maximum sediment concentration that can be left on the bottom after remediation and therefore are called the minimum cleanup level.

The goal of every remediation project is to achieve the no effects level specified in the sediment quality standards. However, some flexibility is available during project design to consider both cost and feasibility. A modified design is allowed if it is justified and final sediment cleanup levels do not exceed the minimum cleanup level values. The sediment cleanup trigger value is set equal to the maximum minor effects level allowed in the sediment impact zone, to avoid overlapping the two standards. As a result, both standards contain the same list of numeric chemical values and biological criteria. Provisions are allowed for achieveing sediment standards through natural recovery, provided this process occurs within 10 years.

Washington's State Department of Ecology currently views the maximum minor effects level as a fixed number that cannot be exceeded during any cleanup action. This strict interpretation was opposed by all representatives of regulated discharge sources, who believe there should be more flexibility in administering the minor effects level. Some dischargers are recommending a risk assessment/risk management approach for making decisions about cleanup levels. Risk management is routinely used at Superfund sites to guide decisions about cleaning up contaminated terrestrial sediment and could be applied to marine sediments.

An alternative methods provision is included in the regulation that would allow the use of risk management if prior approval is granted. However, results of this analysis will not be cause to allow values to exceed the established maximum minor effects level.

Table 2.—Six issues that need appropriate criteria.

- "No effects" numeric sediment standard
- Meaningful biological tests
- Acceptable "minor effects" level
- Time period to achieve compliance
- Trigger for starting clean up evaluation
- Approach for using risk management decisions

Conclusion

The experience gained during development of sediment standards for Washington State indicates that research is needed in several areas. Recommended research topics for EPA (summarized in Table 2) include:

- EPA should verify that numeric sediment standards are set at an appropriate level to define the no effects level for both environmental and human health. Several areas of the country are already developing these values based on the apparent effects threshold approach, which cannot define a true cause-effect relationship for specific chemicals. A different equilibrium partitioning approach is being used by EPA headquarters to develop proposed national sediment standards in coordination as needed.

- EPA should ensure that standard biological test methods are developed and verified as alternatives to numeric sediment criteria. Validation is necessary to ensure that these biological tests are indicative of a true environmental effect in the local receiving water where they are applied. Tests should not be selected just because they are quick and relatively inexpensive to run (for instance, Microtox). Critical decisions regarding expensive sediment remediation projects require meaningful tests.

- EPA should establish an acceptable maximum minor effects level that can be used to prioritize sediment cleanup actions. It is unreasonable to expect all areas to comply with an ideal no effects level, especially in heavily urbanized embayments.

- EPA should establish an appropriate period to reach compliance. This approach would take advantage of natural recovery processes and help prioritize resources for active cleanup projects. Also, EPA should develop and validate mathematical models to predict sediment recovery rates.

- EPA should establish appropriate chemical and/or biological criteria values that could serve as triggers to initiate a cleanup investigation. Provisions should be developed to allow consideration of both cost and technical feasibility in determining the appropriate cleanup level.

- EPA should develop a risk assessment–risk management approach to making decisions about maximum concentrations for sediment impact zones and minimum concentrations for sediment cleanup levels. Ideally, this approach should be consistent with the risk management decision process used to direct cleanup at contaminated terrestrial sites.

A National Sediment Strategy

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Introduction

The Coast Alliance is a national coalition of coastal activists who are dedicated to protecting and wisely managing the resources of this Nation's four coasts: Atlantic, Great Lakes, Pacific, and Gulf of Mexico. We chair a working group of environmental leaders, formed in response to citizen concerns about threats to human health and the environment, that supports creation of a national program to identify, safely manage, and clean up contaminated sediments.

In January 1990, at 13 concurrent press events around the United States, the Coast Alliance and other environmental organizations released a citizens' charter calling for a national program to address problems posed by contaminated sediments. Two hundred and thirty-five local, State, national, and international organizations, representing labor unions and health, fishing, sporting, environmental, and citizen groups, have endorsed this charter.

This presentation briefly outlines the components that citizens believe must be included in a national sediment management strategy that would be implemented by regulatory agencies. Many citizens also believe that these components should be articulated in new national legislation that would provide further direction to Federal and State agencies.

The Six Basic Objectives

Legislation was introduced in the 101st Congress that would have required action on contaminated sediments. The 102nd Congress will probably review this legislation when it begins reauthorizing the Clean Water Act and examining other environmental laws that directly impact sediment quality. Citizen groups have outlined — and the Coast Alliance has endorsed — six basic objectives that should be included in this legislation.

- **Agencies should compile a basic inventory of contaminated sediment sites in coastal, Great Lakes, and riverine waterbodies** to get a better grasp of the extent of sediment contamination. According to *An Overview of Sediment Quality in the United States*, a 1987 study conducted for the U.S. Environmental Protection Agency, "there are hundreds of sites in the United States with in-place pollutants at concentration levels that are of concern to environmental scientists and managers. These sites include all types of water bodies and are found in all regions of the country."

  The study also states that every major harbor in the United States is contaminated from sources upstream, in the adjacent area, and from ship traffic. Therefore, the study concludes, in-place pollutants probably occur in all types of waterbodies within the United States.

  Research conducted by the National Oceanic and Atmospheric Administration (NOAA) echoes this report. Since 1986, NOAA's National Status and Trends Program has been systematically monitoring 200 estuarine and coastal sites, checking mussels, oysters, and sediments for different pollutants. According to testimony given by NOAA in July 1989, "This data reveals the truly national extent of the problem of toxic contamination of sediment, fish and shellfish throughout the Nation's coastal waters." In the U. S. portion of the Great Lakes alone, 27 areas have contaminated sediment, and work done by NOAA and other agencies indicates that our marine coasts are experiencing similar difficulties.

The National Research Council's (NRC) Committee on Contaminated Marine Sediments has concluded, in its 1989 report, that "sediment contamination is widespread throughout U.S. coastal waters and potentially far-reaching in its environmental and public health significance." The NRC listed effects from contaminated sediments in at least two broad arenas: impacts to the aquatic environment and resident or migratory fish, shellfish, birds, and other animals, and human health impacts from a contaminated food chain and direct exposure.

- **Citizen groups also urge creation of an EPA-administered national program to clean up and remediate contaminated sediments.** As part of this program, EPA would develop strategies and incentives that encourage use of new and emerging technologies. Some technologies are being developed by EPA's Assessment and Remediation of Contaminated Sediments Program through its Great Lakes National Program office, as well as the Superfund Innovative Technology Evaluation Program.

  However, decontamination technologies must be developed alongside those for disposal. Confining research and development to in-place capping and other containment techniques is not sufficient. EPA and other agencies must pay attention to decontamination technologies in the work underway on the five priority areas of concern within the Great Lakes. Demonstration projects should be authorized at sites on the marine coasts, as well, to further develop decontamination techniques for marine sediments.

- Citizen groups believe that **sediment quality criteria and standards must be developed** to help protect clean sediments, remediate contaminated sediments, and better manage disposal of sediments in confined disposal facilities and at ocean dumpsites. Strong sediment quality criteria and standards should form the backbone of our national sediment management strategy.

- As part of a management strategy, citizen groups advocate **phasing out open water disposal of contaminated sediments** over, at the maximum, 20 years. Harbor muds are dumped at more than 100 licensed ocean dumpsites annually. Moreover, adequate sediment quality criteria will reveal that contaminated muds are currently ocean-dumped. A phase out must occur if aquatic ecosystems and the important fisheries, wildlife, and recreation values they support are to be fully protected from contaminants.

- **Methods to greatly increase implementation of source control, waste pretreatment, and pollution prevention measures must be implemented.** Citizen groups recommend provisions in the Clean Water Act to control poison runoff and direct discharges into riverine and coastal waters.

- Lastly, **a coordinated funding mechanism to pay for removal and cleanup of sediments must be created.** Different financing mechanisms should be contemplated, including user fees, State and local matching grants, fines for spills and other unintentional releases and discharges, court revenues from actions taken against Clean Water Act and Ocean Dumping Act violators, and creation of a National Contaminated Sediment Restoration Trust Fund.

Conclusion

The need for a comprehensive national sediment strategy that includes these six basic steps has been endorsed by 235 citizen groups. Growing concern over the impacts to the aquatic environment and human health from exposure to contaminated sediments makes the creation and implementation of such a strategy critically important.

Sediment Management at the Port of Oakland

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Introduction

The Port of Oakland must deal with sediment deposited in its berths and navigational channels and dispose of that material in a time of increasing environmental awareness. There are a number of different legislative and regulatory efforts moving toward water quality criteria for marine sediments, including the Torres Bill in California (S.B. 479) and the Mitchell Bill (S.B. 1178), which was considered in the 1990 Congress. The port's efforts and responsibilities provide an in-practice example of the implications of sediment regulation.

The Harbor Deepening Project

The Port of Oakland was one of the innovators of the container trade and at one time accounted for 80 percent of the West Coast traffic in containers. Now, since it is the only major harbor on the Pacific Rim that does not have a depth of -44 mean lower low water, the port's share has slipped to 15 percent of the West Coast traffic. Although there are other reasons for this loss of share, our cargo throughput could be 25 to 33 percent higher with a deeper harbor.

The port began planning for harbor deepening in cooperation with the Army Corps of Engineers in 1974, when deep draft vessels too large for the Panama Canal but ideally suited for the Pacific Rim trade were being planned by shipping companies. Although Congress has authorized and funded the deepening project, neither the port nor the Corps has been able to complete it because of controversy over marine disposal of the dredging material. Nevertheless, shippers have built these larger vessels, which now serve the Pacific Rim, and the port's inability to harbor those vessels has cost it dearly through the loss of shipping traffic.

The controversy over disposal sediment involves the approximately 7 million cubic yards of material that must be removed to deepen the inner and outer harbors (Figs. 1 and 2). Disposal of material dredged from navigational channels in San Francisco Bay has been controversial since the mid-1980s when accumulated sediment at the approved aquatic disposal site near Alcatraz Island started to affect navigation.

Efforts to reduce the mounding by slurrying has reduced the amounts accumulated but has exacerbated concerns about turbidity and bioaccumulation at the site and surrounding areas. In addition, past disposals have left high levels of contaminants, particularly polycyclic aromatic hydro-carbons (PAHs), and there is concern about the potential effects of bioaccumulation in the benthic community and at higher trophic levels.

There are no ocean disposal sites designated within 50 miles of the entrance to San Francisco Bay. A site at the 100 fathom line west of the coast can no longer be used because it is within the boundaries of the Gulf of the Farallons National Marine Sanctuary. Thus, the port is without marine sites for disposal, regardless of the quality of the material.

San Francisco Bay and its estuarine extension into the delta of the Sacramento and San Joaquin

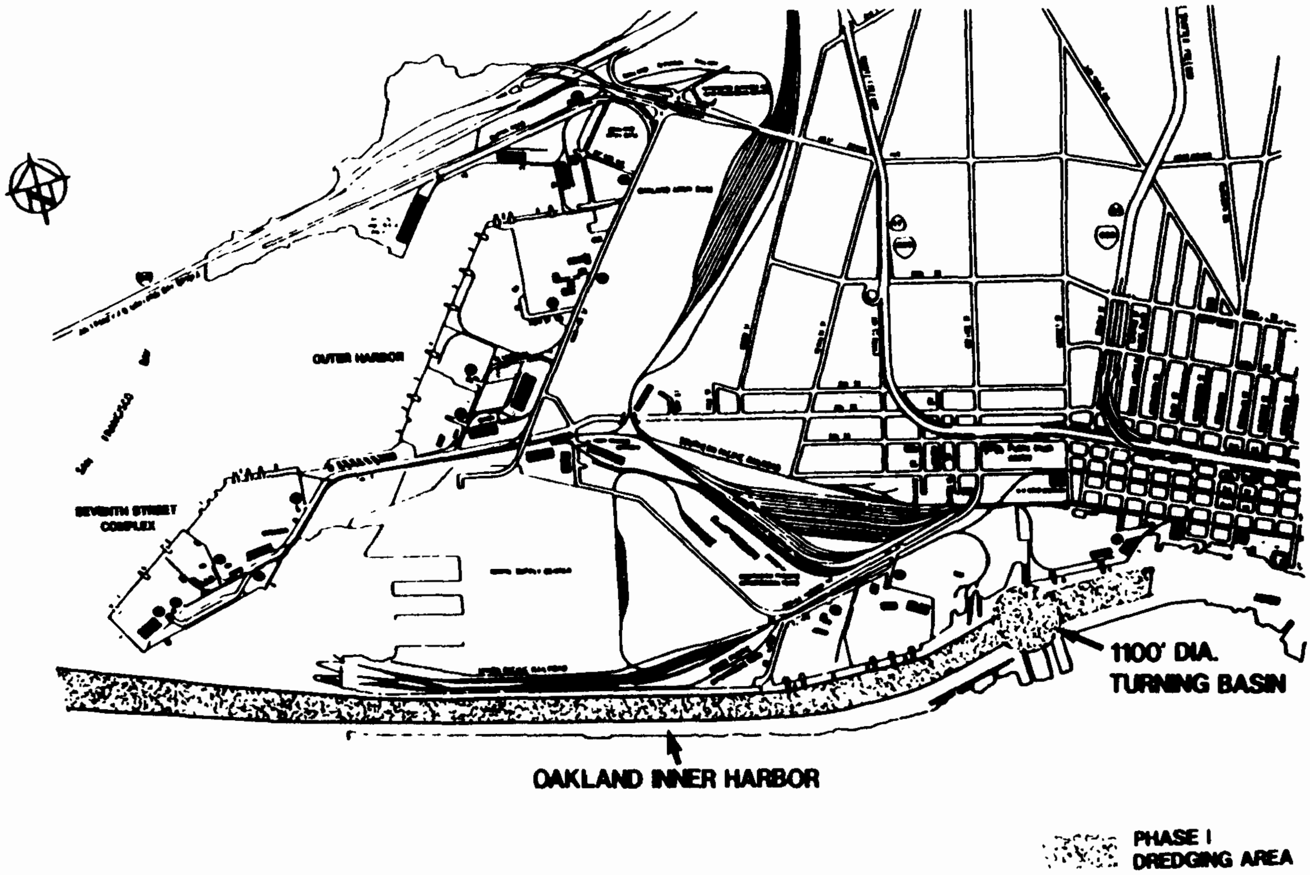

Figure 1.—Oakland Inner harbor, Phase I dredging project.

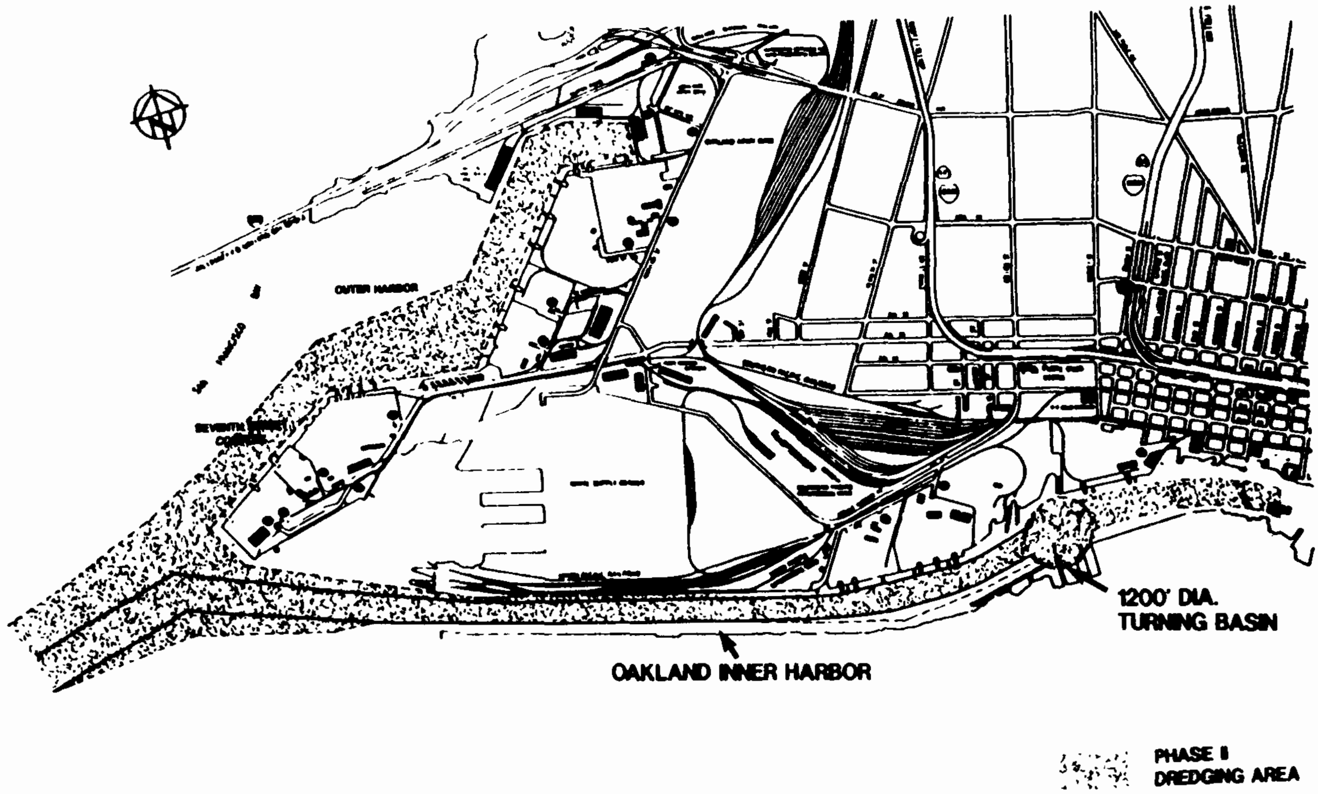

Figure 2.—Oakland Inner harbor, Phase II dredging project.

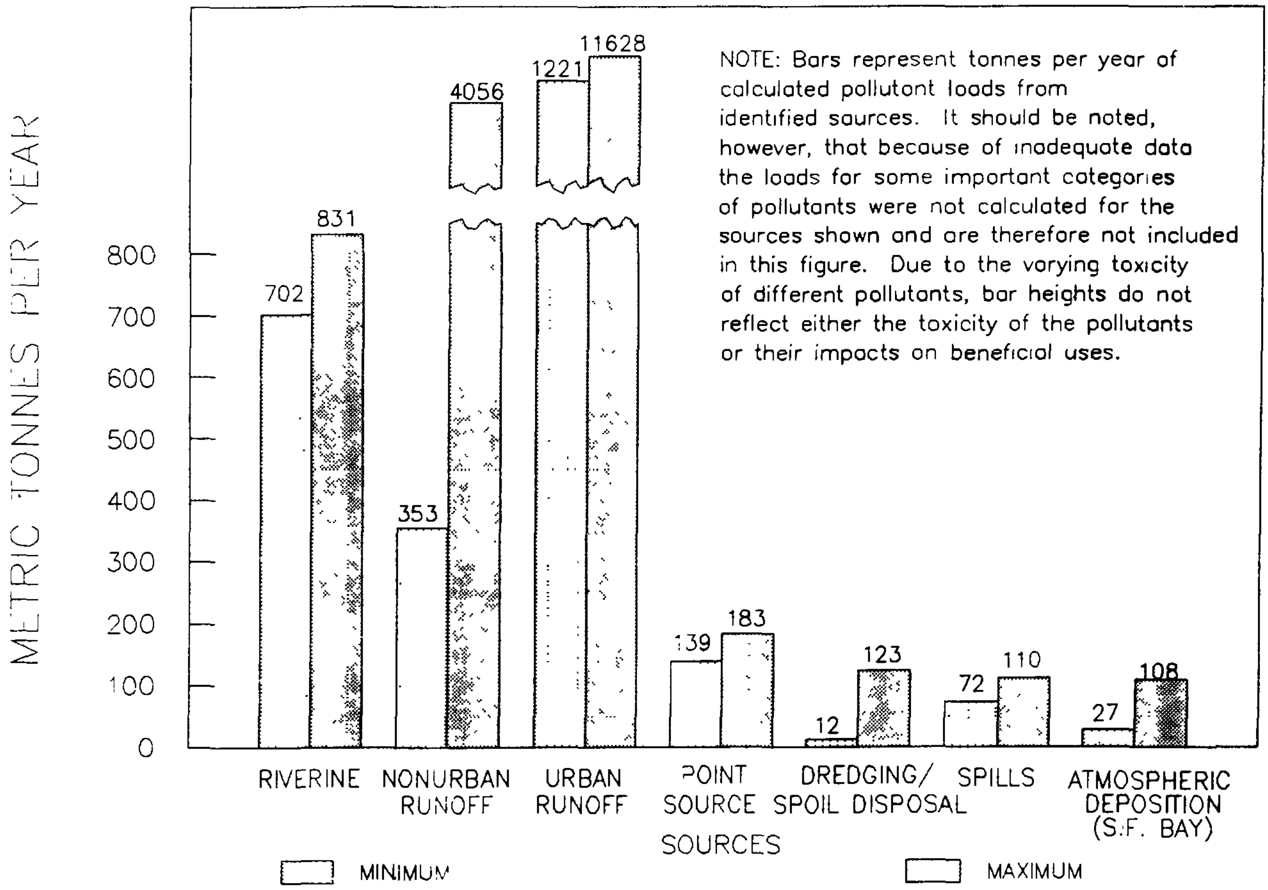

Figure 3.—Pollutant loadings to the bay delta estuary (Source: Calif. State Water Resour. Control Board, 1988).

rivers have been badly stressed by human intervention. Fish populations are declining rapidly: the chinook salmon has been listed as an endangered species because of its 98 percent decline from historic levels despite hatchery efforts; the striped bass population is now less than one-quarter the population level observed in the 1960s; efforts are underway to list the delta smelt as an endangered species; and populations of American shad have also dropped dramatically.

The State Water Resources Control Board (1990) has identified mercury, selenium, and metals contamination, dioxins, organic contamination, and aquatic toxicity as critical water quality problems for the bay and the delta. Mercury, selenium, DDT, and PCBs have bioaccumulated to levels of concern in the estuary. Many problems of the bay and delta appear related to freshwater diversions and habitat losses, but return flow from agricultural irrigation and urban runoff have exacerbated the situation. The loadings from dredging and disposal are relatively small; perhaps 123 metric tonnes out of a total influx of 17,000 metric tonnes annually (0.7 percent) (Calif. State Water Resour. Control Board, 1988), but the public's concern over these contributions remains high.

Contaminants in Dredged Sediment

The levels of contaminants present in dredged sediment are generally fairly slight; however, some contamination will always be present if pollutants are discharged into the estuary. Clay particles float around the estuary and accumulate metal ions and polar organics until they are so large that they settle. There are three general levels of contaminated material: material clean enough to dispose of in the ocean; material that needs some type of management for disposal (confined aquatic disposal); and material that should not be put back into the marine environment, regardless of management.

Virtually any polar organic or metal discharged into an estuary will be found in dredged material, generally at about the same levels as in other sedimentary sites within the estuary. For example, mercury is ubiquitous in San Francisco Bay as a result of gold mining activities during the late 19th century; however, there are no good estimates of how much mercury is tied up in sediments.

For ports, the contaminants of most concern are those discharged directly into the harbor presently and within the past 100 years. For the Port of Oakland, that includes materials associated with shipbuilding (arsenic, copper, and lead from historic paint operations, and tributyl tin from current ships), smelting, petroleum transportation, and fuel burning, particularly coal gassification between the 1860s and 1920s. For ports involved in shipping of petroleum, these products, usually expressed as total recoverable petroleum hydrocarbons, are found at varying levels. PAHs, also found at varying levels, include a wide array of products such as those in urban runoff and the preservative creosote used to treat wood pilings.

Although the public image of polluted material (particularly in the Port of Oakland) is that it is commonly found in and around navigational channels, lakes and estuaries usually contain the worst areas of contaminated sediments. The Great Lakes have serious problems with PCB-contaminated sediments, a significant portion of which reach these waterbodies through aerial deposition.

In California, the most serious problems of contaminated sediments are those associated with discharge of DDT through municipal sewers and the persistence of mercury in sediments from historic mining, particularly gold mining. More than 200 metric tonnes of DDT are still present in the sediments in Southern California. DDT is showing up in fish tissue at alarming levels, as is mercury in San Francisco Bay (Calif. State Water Resour. Control Board, 1990).

As a general rule, navigational channels are less contaminated than a number of areas within the estuary because they have been maintained at -35 feet or more since the 1920s. The Port of Oakland has sampled dredged material repeatedly and is currently awaiting test results completed under the new ocean disposal protocols (U.S. Environ. Prot. Agency/U.S. Army Corps. Eng. 1990). Past tests on the inner harbor sediments resulted in approval of all but 27,000 cubic yards of material for ocean disposal. However, review of those tests and those for maintenance dredging show that there are

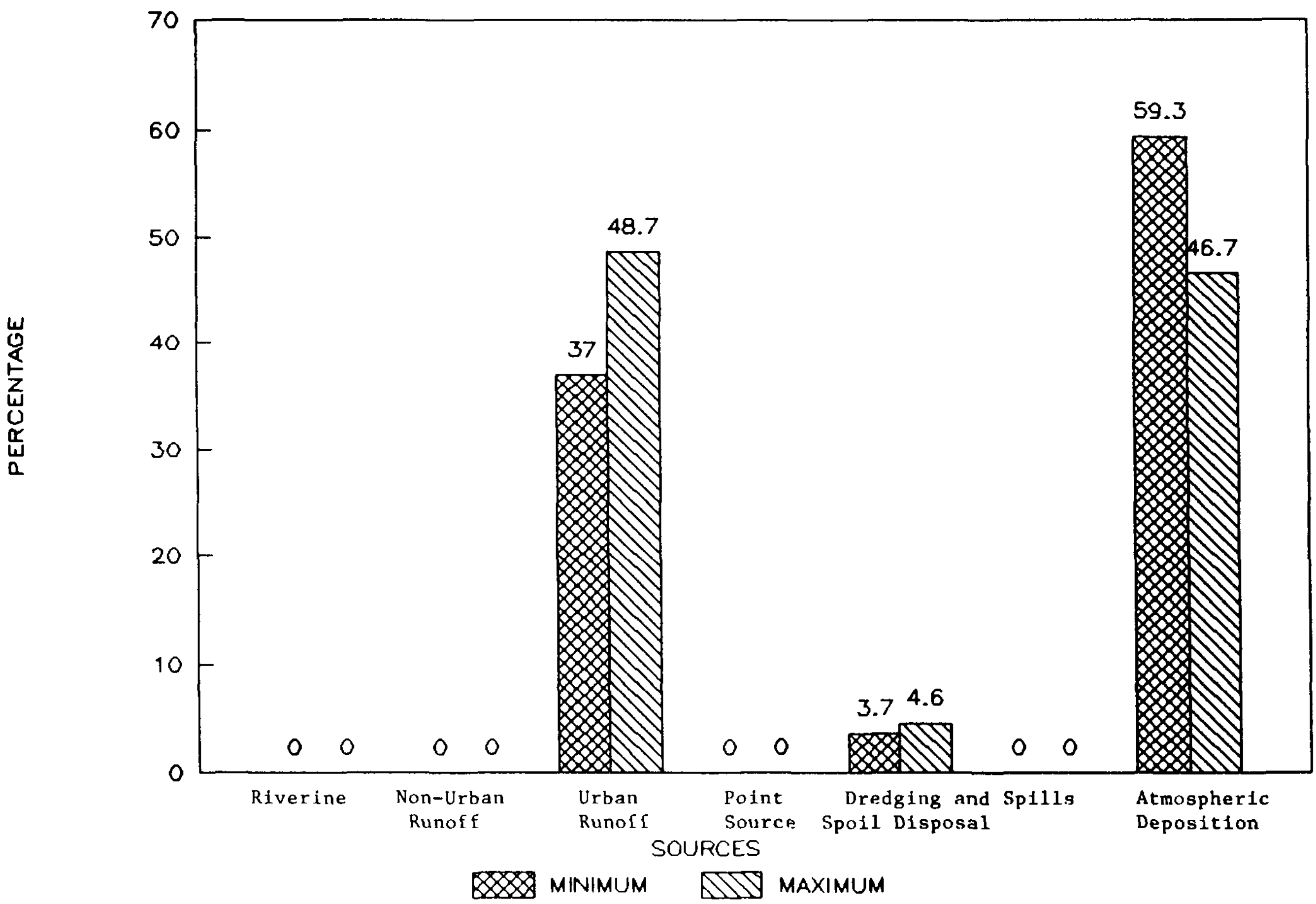

Figure 4. —Pollutant loadings in San Francisco bay delta—hydrocarbons (PAHs) (Source: Calif. State Water Resour. Control Board, 1988).

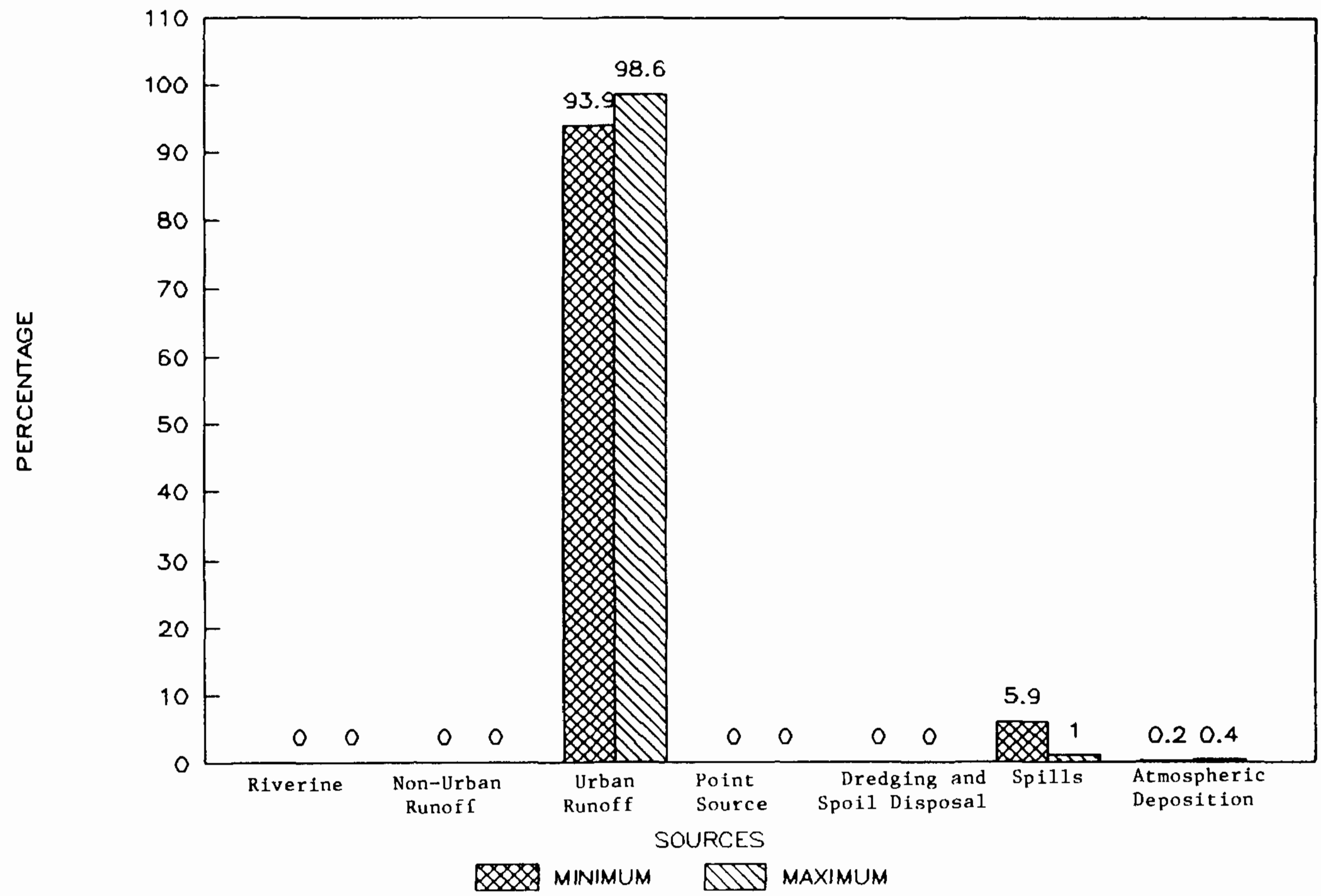

Figure 5. —Pollutant loadings in San Francisco bay delta—total hydrocarbons (oil and grease) (Source: Calif. State Water Resour. Control Board, 1988).

elevated levels of copper, zinc, nickel, and lead in some of the sediments (Battelle Pacific Northw. Lab. 1988; Harding Lawson Ass. 1989).

A small amount (2,500 cubic yards) of sediment that was considered too contaminated for ocean disposal was placed behind the levees at Twitchell Island in the delta formed by the Sacramento and San Joaquin rivers. Monitoring of that sediment revealed that "the total concentrations of heavy metals in the Oakland Inner Harbor sediment are far below the Total Threshold Limiting Concentration. . . It is apparent from all of these comparisons that the degree of contamination of the Oakland Inner Harbor sediment is slight" (Patrick, 1990).

More recent tests of Oakland Harbor sediment show the effects of contaminants in bioassay tests, particularly tributyl tin and PAHs. At times, the sediments routinely removed in maintenance dredging include total PAH levels between 0.5 and 5 parts per million, levels of concern to California because of the potential for bioaccumulation that may, in turn, have significant effects. Therefore, many of the port's current analytical efforts are directed toward evaluating PAH levels.

Sources of Contaminants

There are three general sources of contaminants within a harbor that are different from those generally present in an estuary.

1. Historic land uses have left material directly or indirectly deposited in the estuary. Shipbuilding and coal gassification are the most significant of these uses, but the effects of historic mining activities can still be found in the high levels of mercury.
2. Material is spilled into the harbor from shipping activities, such as loading and fueling. In Oakland, this is less of problem than at any time in the past; petroleum shipping has been phased out as Oakland has become almost exclusively a container port. The advent of larger vessels into Oakland and other ports may mean that older sediment deposits buried under more recent sediments are being pushed around and recycled through biological activity, tides, and currents.
3. Perhaps most significantly, urban runoff is still flowing into our harbors. Relatively lit-

tle is known about the sources of PAHs, but research indicates that they could be coming from urban runoff. As Figures 3 to 5 demonstrate, about 48 percent of the PAHs are coming from urban runoff and about 4 percent from dredged material disposal (Calif. State Water Resour. Control Board, 1988).

The levels of PAH often measured—0.5 to 5 parts per million—may be entirely associated with urban runoff. The contamination might originate in runoff from the port, but the terminal area of the Port of Oakland is just over a square mile, a trivial portion of the urban drainage to the Oakland estuary, much less the bay. Thus, most of this material must be coming from the streets and parking lots of the developed urban areas surrounding San Francisco Bay.

Disposal of Dredged Material

A number of beneficial uses have promise for dredged material: reinforcement of levees in the delta of the Sacramento and San Joaquin rivers, construction of marshes, construction fill, and daily cover in a landfill. The Port of Oakland is presently examining more than eight upland sites as alternatives to marine disposal for the 560,000 cubic yards we seek to dredge to deepen the inner harbor (Fig. 6). Obviously, the quality of the material, both in terms of geophysical properties and contaminants, plays a major role in determining which of these sites is suitable, and the lack of clear guidance or standards on the quality requirements for these beneficial uses complicates our analysis.

California is moving toward sediment criteria rather than standards, and we are working with the State in several projects that would allow upland placement of sediments with elevated concentration of PAHs. However, the bottom line for upland disposal, as with ocean and in-bay disposal, is that no one seems to want this material in his/her backyard. Despite nearly three years of effort, we are not certain that any upland disposal sites will actually be permitted by the end of 1991, when our deepening project is scheduled to begin.

The greatest concern is sediment that contains such high levels of contaminants that it requires management. This sediment has historically been deposited in our waterways and has contributed to our bioaccumulation problems. Just before I left EPA, we were developing the elutriate test, which we thought was the answer to sediment testing questions. Since then, we have dumped a lot of

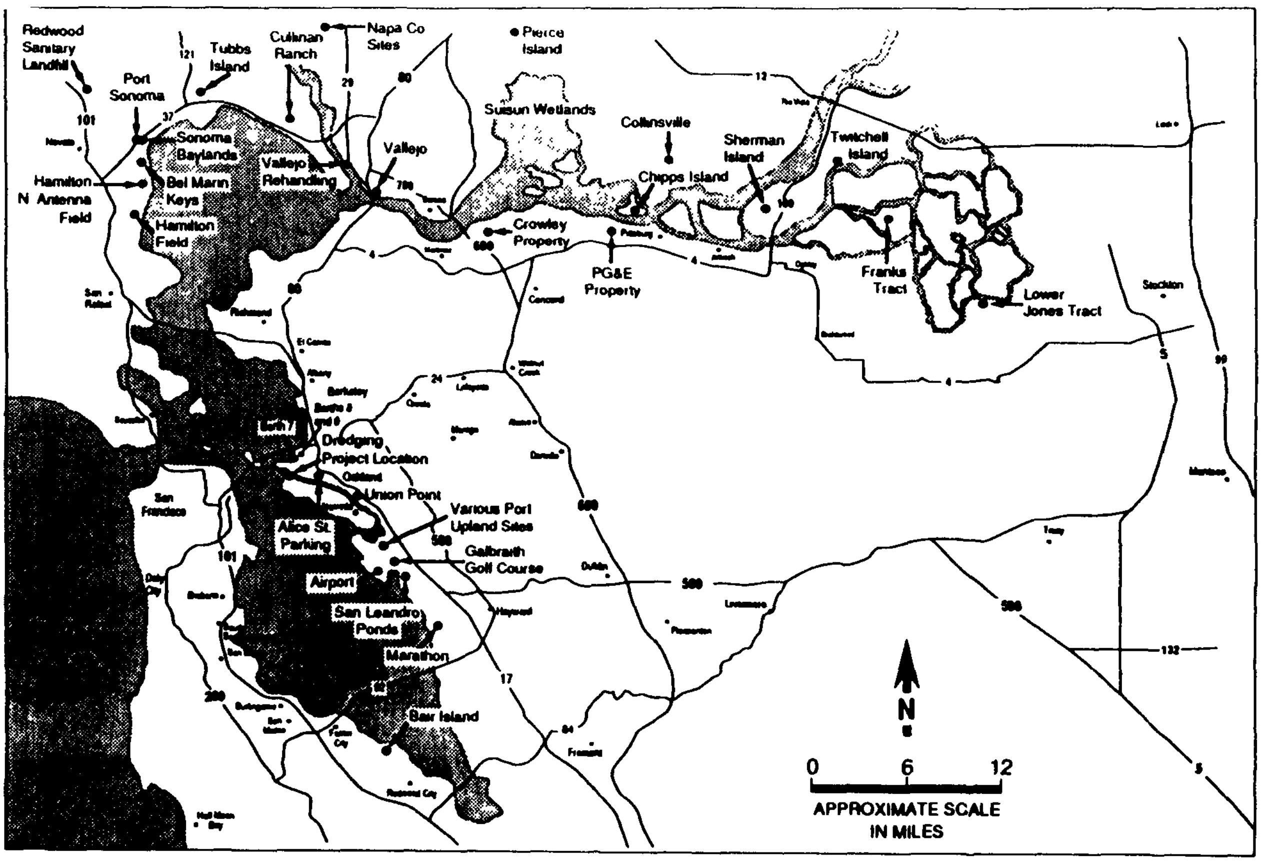

Figure 6.—Upland sites considered for disposal of dredged material.

material high in PAHs in San Francisco Bay that met that test, and those materials that didn't stay at the disposal sites have been recycled through the estuary. When we search for answers, we also must recall that the worst sites are not in the navigational channels but at various places where historic discharge took place.

The chemistry of contaminant movement is fairly elementary. High levels of contaminated metals, and to a lesser extent organics, should be kept saturated. As long as they are saturated, they are bound as low solubility ions and are relatively unavailable except through ingestion and resuspension. The mechanics of movement and resuspension are a little more complicated. Wind, waves, and ships can and do disturb these sediments. We need to make sure that any site used for dredged material reduces the redistribution and biological uptake of these material. We need to consider marine stability as well; seafloor landslides may be the biggest risk for spreading DDT sediments in Santa Monica Bay.

The economic picture is most complicated for ports, given their role as keepers of channels. Dredging with disposal in San Francisco Bay costs the Port of Oakland about $2 per cubic yard when economies of scale are achieved. Disposal at an approved site at 50 fathoms 23 miles offshore was contracted at a cost of $3.50 per cubic yard. Our best estimates for marsh creation is $13.50 per cubic yard, and upland disposal as daily cover in a landfill, $20 to $30 per cubic yard—if any landfill will accept the material.

Disposal of hazardous waste costs over $300 a cubic yard, but we have not found any hazardous material in the areas to be dredged. However, establishment of a new upland disposal site for dredged material may involve many aspects of siting a new sanitary landfill. Certainly some upland disposal will be required of some material found in navigational channels. However, for the Port of Oakland, pressures to seek upland disposal of material that would meet the criteria for ocean or bay disposal might render harbor deepening economically infeasible because upland disposal could add as much as $70 million to the cost of a project presently estimated at $80 million. The port could not afford to deepen the harbor if the project cost increased by $70 million. If that happens, contaminated material that would have been removed to an upland site in harbor deepening will, in fact, be left in the water.

Conclusions

To my mind, the only solution that will reduce the exposure of marine organisms to contaminants in the next 20 years is confined aquatic disposal. In San Francisco Bay, there is a pit from which 22,000,000 cubic yards of sand were mined. This pit could be used for disposal of dredged material at an estimated cost of $2 to $6 per cubic yard. The site is located where wave and currents would not redistribute dredge material.

To the San Francisco Bay environmental community, suggesting use of this site for dredge disposal is synonymous with heresy. However, only through solutions in an economic range that allow cleanup of existing problems can the nation's ports, through their navigation projects, be part of the solution. The regulatory and the regulated communities must cooperate to find creative solutions to the problems of contaminants that are already in our waterways, to prevent new contaminants from reaching those waters, and to remediate sites that are contributing to contamination. We must also recognize that sediments already in the water must be managed.

When accomplishing that task, if we panic over evaluation and regulation of sediments that contain small concentrations of contaminants but need management, then the real problem, the badly contaminated sediments, stay in the water while we argue. The current stalemate serves neither the shipping industry nor the environment.

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INDUSTRY'S PERSPECTIVE ON WATER QUALITY STANDARDS

Water Quality Criteria and Standards: An Industrial Viewpoint

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Introduction

Water quality in the United States has improved significantly in the past 20 years. Industrial pollution is now less than 10 percent of the remaining contamination in the Nation's waters (U.S. Environ. Prot. Agency, 1990). Nonpoint sources, combined stormsewer overflows, and municipal wastewater treatment facilities remain the major sources of water pollution. We should pause and recognize this progress as we address the remaining contamination.

Water quality criteria and water quality standards have been fundamental to the Clean Water Act from the beginning. The first criteria were developed by a group of external experts; only later did the U.S. Environmental Protection Agency (EPA) assume this role.

Problems of setting acceptable levels for criteria have continuously plagued scientists. In the beginning, few toxicological or environmental data existed to support the levels set by criteria documents. Later, levels of toxic materials were set at or below levels of detection with little regard to the actual toxicity of the materials in question. The theory was that any level of a toxicant was too much; yet, toxicity is the combination of the inherent properties of the material, the concentration of the material, and the exposure. All too often these factors are not considered in conjunction with each other.

The practice of risk assessment has matured considerably since the original water quality criteria were developed, and the latest versions of the human health criteria, now 10 years old, do not reflect this greater understanding of risk assessment technology.

States' use of water quality standards is often in conflict with the discharge permits. The assumption is that control of point discharges will result in control of water quality. When the water quality standards are not met, regulators and the public often expect additional controls on the level of industrial discharges. However, if industrial point discharges represent less than 12 percent of the remaining water pollution (Counc. Environ. Qual. 1987), total removal will still not address the remaining 88 percent. Furthermore, standards should not be set at levels below analytical detection because they cannot be enforced.

Risk Assessment Methodology

Risk assessment methodology is a viable tool in setting water quality criteria. EPA should review the standards based on proper risk assessment methodology. Furthermore, current risk assessment procedures used by the EPA should be modified in the following areas:

- Risk assessment should be purged of conservatism or margins of safety that are clearly risk management decisions. No policy assumptions should be made in calculating risks.
- The linear multistage model is unjustified as a method of scientific risk assessment. Risk assessments should use most likely estimates of risk and exposure, not worst case assumptions.
- When available, human epidemiological data that are valid should be incorporated into the

risk assessment and given more weight than animal toxicological studies.

- Animal extrapolations are problematic and may be misleading when animal tests are conducted under the maximum tolerated dose requirement. Combining benign and malignant tumors when not scientifically justified and preferentially using surface area over body weight for extrapolation factors are questionable practices for quantifying potential risks.
- Risk assessments should shift to a weight of the evidence approach by incorporating data from positive and negative studies. Uncertainty in a risk assessment should be quantified. Full disclosure of assumptions and their implications for risk management decisions should be provided.

Many experts are calling for improvements in the practice of risk assessment. The EPA is aware of these changes, and they are changing their older practices of risk assessment in many areas. Water quality criteria are due for a reevaluation based on the improved techniques.

Should the list of priority pollutants be evaluated against a risk assessment background? Current data on their toxicity might indicate that many pollutants may not belong on the list. Perhaps others should be added. Once again, the change in the list should be based on scientific risk assessment technology.

Public Participation in Developing Criteria

Currently, industry and other interested groups contribute to the development of supporting materials for the water quality criteria and standards. They provide information on the compounds' toxicology and, in some cases, epidemiology. When industry is only invited to comment on the proposed final document, its ability to provide useful input is limited. By the time that industry provides comments, the Agency is less inclined to incorporate the information. The comment period is often too short, which affects the quality of the input.

States should use the industrial groups in their area to get support for standards development. For example, many States have chemical industry councils and all States have State chambers of commerce. The overall quality of the product would benefit from cooperation between industry and other groups with State governments.

State Standards

States should set their water quality standards according to local conditions. The law is structured so that the States can issue their own standards, with EPA approval. EPA should not usurp their authority by imposing its proposed toxics rule.

Setting criteria at levels that cannot be measured is unreasonable. Levels should be set on the basis of risk—not on the levels on nondetection, an approach that lacks all scientific support. Forcing States to incorporate this scientifically unsupportable approach does little to improve water quality.

The Clean Water Act's national policy is "that the discharge of toxic pollutants in toxic amounts are prohibited." Using criteria set below the detection limit is not addressing the issue scientifically because these "detectable limits" levels are generally below toxic amounts.

Watershed-based Standards

Less than 10 percent of the remaining water pollution comes from all industrial sources (U.S. Environ. Prot. Agency, 1990). Between 1960 and 1988, this Nation reduced the population served by less than secondary wastewater treatment from 36 million to 26.5 million, but the population not served at all is essentially the same as it was in 1960: 70 million (Table 1) (Counc. Environ. Qual. 1990). While this is a significant improvement, it does not meet the Nation's needs.

Further tightening of industrial point source permits will do little to improve overall water

Table 1.—Population served by municipal wastewater treatment systems, by level of treatment, 1960–88.

	(MILLIONS OF PEOPLE)				
LEVEL OF TREATMENT	1960	1978	1982	1986	1988
Not served	70.0	66.0	62.0	67.8	69.9
No discharge	na*	na	na	5.7	6.1
Raw discharge	na	na	na	1.6	1.4
Less than secondary treatment	36.0	237.0	37.0	28.8	26.5
Secondary treatment	na	56.0	63.0	72.3	78.0
Greater than secondary treatment	4.0	49.0	53.0	54.9	65.7

* Not available.
Source Council on Environmental Quality, 1990.

quality while increasing costs considerably. The chemical industry spent $650 million in capital costs for wastewater treatment in 1989, and gross costs for water treatment were $1.5 billion. Capital costs grew 25.1 percent annually between 1984 and 1989. (Chem. Manuf. Ass. 1990). The primary way that water quality should be approached at this point is on a watershed basis. The entire area should be studied and controls for water quality should be based on the sources of contamination.

Section 208 of the 1972 Amendments to the Clean Water Act was designed to coordinate water quality programs. Over time, many documents were produced but State governments failed to coordinate programs or set priorities for investment based on watersheds.

Sediment Criteria

EPA's sediment studies have lacked field data support; therefore, the current attempt to develop sediment criteria needs additional validation before these standards are applied in a regulatory environment. Sediment chemistry is quite complex; many laboratories are unprepared to do analyses with the level of confidence necessary for regulatory application. The methods must be tested in a variety of sediment types and salinity variations.

Conclusions

Water quality criteria and standards played a large part in helping to clean our Nation's waters. It is time to reexamine the foundation of the criteria on the basis of the new risk assessment structures. The water quality criteria and standards process could be improved by more participation by industry and other groups with technical information and experience at an earlier point in the process.

Future water improvements must focus on the remaining significant sources of the problem—nonpoint sources, municipal wastewater treatment facilities, and combined storm overflows.

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CONTAMINATED SEDIMENT ASSESSMENT

Assessment of Contaminated Sediments

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Introduction

There is no longer any doubt that contaminated sediments are found throughout this Nation's freshwater and marine coasts and within our lakes and rivers. And there is little disagreement that remedial action should be taken where sediments are severely contaminated. Despite this fact, money or appropriate management options are usually extremely limited. The difficulty lies in knowing at what point sediment-bound toxicants begin affecting the environment adversely. Because of this problem, identification and remediation of these areas have been limited. However, contaminated sediments must be identified for appropriate management and remedial action and be incorporated into the water quality framework that government regulators and private sector managers work with every day. Ultimately, the impact of sediment quality on the environment and public health should be assessed to protect clean sediments sufficiently and allow clean up of already contaminated sediments by increasing pollution control and natural sedimentation. Otherwise, this Nation will never meet the Congressional mandate to restore the physical, chemical, and biological integrity of our waterways.

The increasing number of Federal, State, and local research and management programs underway to characterize the quality of coastal areas and identify and implement necessary remedies make sediment assessments mandatory. Metropolitan New York City alone haa three major Federal programs: the Long Island Sound Study, the New York-New Jersey Harbor Estuary Program, and the New York Bight Restoration Program. In addition, combined sewer overflow abatement and stormwater controls are being planned, direct discharge permits are being renewed with tighter limits, and pretreatment programs are slowly being implemented, all with the objective of meeting State water quality standards in coastal receiving waters. The issue of sediment quality is just beginning to weigh in — and only on a very limited basis.

Lack of Federal Standards

Thus far, the U.S. Environmental Protection Agency (EPA) has done little to promote sediment quality assessment in such regulatory programs as the Federal Estuary Program. The longer EPA pursues this course, the stronger the likelihood that all types of Federal, State, and local agency programs will be implemented without considering the impacts on sediment quality.

The lack of Federal numeric criteria or standards is a commonly cited reason for not assessing sediments or factoring them into environmental programs. Without an enforceable, legally defensible standard, there is substantial institutional reluctance to require remedies. Also, until recently, no appropriate benchmarks existed that could even indicate potential adverse effects caused by pollutants in sediments. Consequently, sediment chemistry data collected by universities and regulatory agencies are mostly ignored because of this gap in knowledge. Pollutant concentrations in sediments are compared to other data sets from around the country to gauge a degree of contamination, but even that kind of analysis convinces few agencies that a problem even exists, much less that something needs to be done.

This is particularly troubling for areas such as the New York-New Jersey Harbor because, out of all the problems it is experiencing, toxics (particularly heavy metals) have been identified as a major priority. Metals tend to be in particulate form and accumulate predominantly in sediments. The major source of toxic pollutants entering the New York Bight is dredged sediments from the New York-New Jersey Harbor that have been deposited in the open ocean off the New Jersey coast. Therefore, a huge opportunity will be missed if management plans and water quality control measures devised for these coastal areas do not include solutions that will clean up those contaminated sediments.

Assessment Methods

How can we overcome this problem? Despite the lack of Federal criteria, other States and regions are setting standards to assess sediments and guide policy on managing contaminated sediment. Current methods include the apparent effect threshold approach (AET), used to quantify sediment concentrations above which statistically significant biological effects always occur. These values have been used by the Puget Sound Dredge Disposal Analysis to prepare screening and maximum levels and are the basis for Washington State sediment quality standards.

The screening level concentrations and bioeffects/contaminant co-occurrence analyses approaches are similar to AET in that they rely on field-collected data. The spiked-sediment bioassay approach is a laboratory-based method whereby organisms are exposed to pristine sediments that have been spiked with known amounts of pollutants.

Other approaches include the background approach, where criteria are set at some specified level above background concentrations, and lastly, the sediment–water equilibrium partitioning approach, which sets criteria at the sediment concentration in interstitial water that does not exceed EPA water quality criteria. EPA used this method to develop its recent interim criteria for non-polar organic chemicals and is researching and refining this approach to develop criteria for metals. However, these regional or State criteria are not used in areas other than those they were developed for because of their many shortcomings.

Federal Surveys

Despite the absence of Federal numeric criteria, several surveys have been conducted by EPA and the National Oceanic and Atmospheric Administration (NOAA) to determine the extent of contaminated sediments. NOAA's National Status and Trends program is the best Federal effort currently being made to document the quality of marine coastal sediments. This program surveys 200 marine coastal sites around the United States yearly and reports on the concentration of heavy metals and organic chemicals in sediments and the tissues of mussels and oysters. Major findings of this ongoing survey have included identification of urban harbors on both coasts with the highest levels of pollutants (Natl. Ocean. Atmos. Admn. 1988) as well as increasing and decreasing trends indicated by three years of data on levels of pollutants in mussel and oyster tissues (Natl. Ocean. Atmos. Admn. 1989).

In March 1990, NOAA's Seattle office issued a report that shed substantial light on which sites have the highest potential for adverse biological effects (Long and Morgan, 1990). By reviewing data derived from these methods and approaches, informal guidelines were identified that indicate concentrations at which biological effects are likely to be observed. The report included lower 10 percentile and median concentrations and an overall apparent effects threshold concentration for 11 metals, total PCBs, 11 pesticides, and 20 polynuclear aromatic hydrocarbons. These guidelines were developed specifically to help interpret the National Status and Trends program sediment data.

NOAA now ranks the program's 150 sites according to those with the highest potential for toxic effects. A site in the Hudson-Raritan estuary that topped the list of the 30 most contaminated areas is followed closely by four others in the same waterbody.

How can these guidelines be useful outside of the National Status and Trends program? Although they have no regulatory authority, the guidelines do provide a starting point for ascertaining where in a waterbody biological effects occur when sediments are contaminated. In other words, if a waterbody has levels of a pollutant in its sediments that are higher than the guidelines and there is a good degree of confidence in that guideline, there is reason to recognize that a problem may exist and to consider possible strategies to address it.

Conducting such an exercise can also highlight which pollutants may be posing the most risk and which areas of a waterbody should be given priority if there are many pollutants above the guidelines. Lastly, it can be used to check against the bulk chemistry data for pollutants in sediments found suitable for dredging and open ocean disposal through the bioeffects tests currently used by the U.S. Army Corps of Engineers and EPA. All in all, the guidelines provide a means of doing some sort of assessment until Federal sediment quality criteria are available. Serious consideration should be given to using these guidelines in a national inventory of sediment quality to help characterize this environmental problem on a wider scale.

Potential Uses for Criteria

Cleanups

One of the main concerns the Environmental Defense Fund has with the development of Federal sediment quality criteria is how potential uses drive their stringency. Sediment quality criteria must be fully protective of the most sensitive of aquatic organisms and should protect unpolluted sites. This premium on sensitivity demands that only those pollutant levels with some degree of certain safety be allowed to build up.

When sediment criteria are used to justify clean-ups, the premium is on demonstrable evidence; only those sediments that are known with some degree of certainty to be contaminated will warrant the expense of cleanup. Because of scientific uncertainty, the gap between a demonstrable standard and a sensitive standard can be quite large. The concentration of a chemical that has demonstrable effects is generally going to be different from the one that is known to be safe. Thus, the size of the gray area in between is likely to be significant.

Federal EPA sediment criteria should not represent a compromise between demonstrability and sensitivity. They should be set to protect clean sediments. Thus, numeric sediment criteria should be used to drive pollution controls to an appropriate level that will protect clean sediments and also ultimately improve sediment quality by effectively reducing pollutant discharges. Detoxifying every ounce of sediment that exceeds the criteria is nonsensical; instead, agencies should be ratcheting down on pollutant discharges so that their concentration in sediments eventually meets the numeric criteria. Sediment quality criteria should be used as water quality standards are: to strengthen discharge permits and nonpoint source abatement requirements.

For that matter, sediment quality criteria should also be used to develop limits on air emission which are a dominant source of sediment contamination in many regions, among them the Great Lakes. Meeting and maintaining sediment quality should be one of the driving forces in wasteload allocation models that determine which level of pollutant discharge by all sources is allowable in a waterbody.

This general idea is being incorporated into policy by the California State Water Resources Board to establish mass emissions for pollutants to control accumulation in sediments and biota (Calif. State Water Resour. Control Board, 1989). Additionally, when feasible, emissions will be frozen to current loading levels to prevent increases in sediment or biota contamination. The Environmental Defense Fund has advocated use of available indicators of potentially harmful contamination levels to trigger this type of emissions strategy (Environ. Def. Fund, 1989). Other States and regions would substantially benefit from studying this strategy and using it as a model to guide policies on improving and restoring waterbodies from all types of pollutant sources.

Open Ocean Disposal

Sediment quality criteria also must be used to determine which sediments are appropriate for open ocean disposal. The effects-based tests devised by EPA and the Corps are no substitute for numeric criteria, which must be incorporated into the decisionmaking process. In fact, the Environmental Defense Fund maintains that the current effects-based approach fails to protect oceans and aquatic organisms from contaminated sediments and numeric criteria are urgently needed to provide a better measure of environmental protection. Ultimately, contaminated sediments should not be disposed of in the ocean, and numeric criteria should be used to assess what is and is not contaminated so that dredge material of varying quality is more properly managed.

There is substantial disagreement about the degree to which sediments are contaminated in the New York-New Jersey Harbor, in large part because of the Corps' position on sediment testing and open ocean dumping criteria. According to the Corps, 95 percent of all sediments tested meet the appropriate criteria and are deemed suitable for open ocean disposal, because "it will not cause adverse environmental impact." Rather infrequently does the Army Corps find sediments from navigational projects that need capping.

It is difficult to reconcile this position with the evidence that:

- Dredge material constitutes the largest source of pollutants entering the New York Bight;
- Sediments and biota at the mud dump site have elevated levels of pollutants; and
- NOAA has documented sites in the Hudson-Raritan rivers to have some of the most enriched sediments nationwide at levels that have the potential to cause adverse biological effects.

This is a case where numeric sediment quality criteria would substantially help put to rest the debate over which dredged sediments in the New York-New Jersey Harbor are appropriate for open ocean disposal.

Conclusions

The Environmental Defense Fund believes present indicators of sediment contamination can be used now to assess sediments and guide policy about their management. EPA's numeric criteria should benefit from these indicators and, once they are derived, be the basis for standards that apply to a variety of regulatory contexts. Setting numeric criteria and standards is a major research and regulatory undertaking that is breaking new scientific ground in the field of environmental science. Applying sediment quality criteria and standards and effecting better environmental protection of our Nation's waters will be one of EPA's biggest challenges.

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Sediment Assessment for the 21st Century: An Integrated Biological and Chemical Approach

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Introduction

As we look forward to the 21st century, assessment of sediment quality appears to be one of several critical environmental issues. This issue is documented by a wealth of sediment monitoring data in the STORET database (Bolton et al. 1985), Superfund monitoring activities, and numerous individual sediment monitoring publications (Lyman et al. 1987). However, the extent and significance of sediment contamination have not been explored in any concerted, national manner (Natl. Res. Counc. 1989), and there is considerable uncertainty as to the potential impact on the aquatic environment. In response to the concerns about contamination, research underway in government, academia, and industry is aimed at understanding the mechanisms of chemical transport, fate, and aquatic toxicity associated with sediments.

Do We Need Sediment Quality Criteria?

The answer to this question depends to a large extent on whether existing regulations under the Clean Water Act (such as water quality standards and the National Pollutant Discharge Elimination System (NPDES)) are adequate to protect the aquatic environment. The most common reasons given for establishing sediment quality criteria are to provide additional statutory authority and/or to establish uniform national standards (Cowan and Zarba, 1987). Table 1 has summarized previously reported reasons for establishing sediment criteria.

The information in Table 1 suggests that sediment quality criteria may not be needed or may not be appropriate. Foremost among the reasons for this conclusion are that present methods for deriving these criteria result in too much uncertainty associated with the resulting values to use them for sediment quality standards in regulatory actions. Numbers derived by any of the present methods should be considered qualitative, not quantitative.

Additionally, the word "criteria" carries with it a certain statutory connotation that hinders use of sediment quality criteria numbers as screening level tools. We believe that the numbers derived by present methods for sediments are best represented as sediment assessment values that could be used for screening to determine whether additional toxicological and chemical investigations are needed.

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Table 1.—Sediment quality criteria—are they needed?

PERCEIVED NEED	WHY THEY ARE NOT NEEDED
To protect the environment by establishing national sediment quality objectives	There is too much uncertainty associated with sediment quality criteria derived by current methods.
	Sediment contamination is primarily the result of historical events that are now regulated.
To provide cleanup standards	Cleanup decisions can be made using integrated chemical and biological sediment assessment methods. Decisions based upon cleanup standards or criteria are only as good as the standards.
To afford a means of controlling end-of-pipe chemical concentrations	Chemicals in effluents are currently regulated by NPDES permits, water quality criteria, effluent guidelines, whole effluent toxicity tests, and the reportable quantities statutes. Additional regulations would be redundant and unnecessary. Regulatory authority exists to control levels of chemicals in effluents.
To provide regulation of open water disposal of sediments	Open water disposal of sediments is regulated by the Clean Water Act, Dumping Permit Criteria, section 103 of the Ocean Dumping Act, and the London Dumping Accords. Issuance of permits currently requires bioassays to demonstrate lack of toxicity and bioaccumulation before a permit is issued.

Our review of present regulatory authorities further indicates that means exist to adequately control releases of substances to the environment. Discharge of chemicals are currently regulated through NPDES permits, water quality standards, effluent guidelines, whole effluent toxicity tests, and reportable quantities regulations. Additionally, compliance with section 404(b)(1) of the Clean Water Act, dumping permit criteria, and section 103 of the Ocean Dumping Act require the avoidance of "unacceptable adverse effects" when disposing of dredged sediment. Therefore, the need for additional regulation does not appear to be overwhelmingly obvious.

What is obvious is that sediments must be protected. It is our contention that this can be achieved within the existing framework of regulations, statutes, and assessment methods.

Can Sediment Standards Protect Sediment-dwelling Organisms?

Sediment standards have been proposed to control point source discharges by requiring that sediment levels below a permitted discharge point not exceed some stated levels and also that suspended solids in water leaving a permitted facility not contain chemical concentrations above sediment standards. Excessive amounts of chemicals in aquatic sediments near permitted discharges most often result from one or more releases of chemicals that stem from a failure of the treatment equipment or some other event. Sediment standards, like those for water quality criteria, will not protect against episodic discharges of chemicals in permitted outfalls.

There are significant consequences of further controlling chemicals on suspended solids concentrations through effluent particulate limits. Most permitted effluents have stringent suspended solid permit limits (10 to 20 mg/L). Further restrictions will require additional technology, such as sand filters. Implementation of this technology across the United States will not eliminate the discharge of chemicals and would require a major expenditure of millions of dollars by industry, government, and municipalities. The amount of discharged solids would be reduced, but the total benefit to the environment in terms of load to the ecosystem and concentrations in sediments below an outfall could not be expected to improve significantly. This is primarily because the largest contributor to sediment chemical concentrations is effluent excursions.

EPA recognizes that the best available source control will still result in suspended solid deposition near the discharge point (PIT Environ. Serv. 1988). EPA also knows that a sediment dilution zone is needed near the discharge point to accommodate permitted daily discharges. Therefore, we contend that promulgation of sediment standards to control point source chemical discharges will be of little aid for environmental protection.

Do Existing Water Quality Criteria Adequately Protect Sediment-dwelling Organisms?

Existing water quality criteria and standards do protect sediment-dwelling organisms—when they are not exceeded. This premise is based on a wealth of experience dealing with laboratory and field data and on the thermodynamic laws that govern adsorption and desorption of chemicals to and from sediments.

In brief, the theory associated with adsorption and desorption can be summarized as follows. The bioavailability of compounds in sediments and their potential to interact with benthic organisms are directly related to the extent these compounds are adsorbed to sediment and controlled by the equilibria established between sediment, pore water, and surface water. The extent of adsorption is a function of the compounds' chemical properties and the sediment's physical and chemical properties. Non-ionic organics, which comprise a majority of commercial chemicals, will adsorb to sediments in inverse proportion to their water solubility. Their affinity for sediments can be measured experimentally by batch sediment adsorption isotherm studies, which provide a measure of the sediment–water partition coefficient (Kp). This value is predictive for most sediment types if it is normalized for the organic carbon content of different sediments (Kp=Koc x Foc; where Koc=carbon normalized sediment partition coefficient and Foc=fraction organic carbon) (Karickhoff et al. 1979). Chemical affinity for sediments can be estimated from a chemical's octanol–water partition coefficient (Kow).

For ionic organic compounds, adsorption to sediment is thought to be a function of the sediment's carbon content and cation exchange capacity (DiToro et al. 1989). With respect to ionic inorganics, such as metals, an estimate of adsorptive capacity potentially can be derived from a measure of the acid-volatile sulfide content of the sediment (DiToro et al. 1990). As the previous discussion describes, there are experimental and theoretical methods for measuring or estimating sediment water partition coefficients and the resulting equilibria between sediment and water.

The sediment–water partition coefficient describes the extent of partitioning that can be expected for a specific type of sediment for a particular chemical. When a chemical is discharged in an effluent into a receiving water over an extended period, partitioning to the sediment can be expected in general accordance with the partition coefficient. Chemicals behave according to the laws that govern sorption. There is a point of equilibrium where the desorption rate equals the adsorption rate and no further net gain of the chemical to the sediment is expected as long as the chemical concentration remains constant in the water phase. If an assumption is made that the chemical concentration in the water is always at or below the water quality criteria specified for that chemical, then the concentration in the sediment should always be at or below one that would be toxic to benthic organisms. Therefore, if the water phase concentration is always below the criteria, chemicals would not be expected to accumulate in sediments over long periods until the concentration becomes toxic to benthic organisms.

The equilibrium partition theory would also predict that, when chemical concentrations in surface waters are excessive and toxic for an extended period, the equilibria established between the sediment and the sediment pore water may also result in toxic pore water concentrations. Conversely, low or acceptable concentrations, such as water quality criteria, would not pose hazards to sediment-dwelling organisms.

This is the linchpin assumption of the equilibrium approach. Should this assumption be proven incorrect, reliance on a single approach for deriving sediment quality criteria from water quality criteria may result in both underestimations and overestimations of the potential effects on benthic species.

As EPA pursues the appropriate use of equilibrium partitioning (EP) theory and models, it should recognize that a corollary of the EP theory is that concentrations of chemicals in effluents at or below 30-day average water quality criteria are protective of sediment-dwelling organisms. However, because of the qualitative nature of the parameter estimation, equilibrium partitioning results in a sediment assessment value that is best used as a screening tool to assess whether adequate safety can be assured for sediments.

Should the Water Quality Criteria Concept or Another Approach Be Applied to Sediments?

The water quality criteria concept was developed in the 1960s and early 1970s to protect our Nation's surface waters by regulating ambient water concentrations of individual chemicals. An ambient concentration protective of aquatic life has been derived through extensive acute and chronic aquatic testing of many different species. The test results comprise a data set called "water quality criteria." These criteria are, in turn, used to establish water quality standards. The question now arises, should we use this established approach to regulate chemical concentrations in our Nation's sediments?

It is our contention that direct use of water quality criteria for developing sediment quality criteria is not the best or only way to protect sediments. While we believe that the water quality criteria concept has protected surface waters (Kimerle, 1988; Kimerle et al. 1989), direct application of this approach for sediments will be cumbersome and not as scientifically sound. The water quality criteria approach is a lengthy and slow process, requiring 16 acute toxicity tests plus three chronic tests and a measure of bioconcentration for at least one species.

For the past 15 years, it has been EPA's intent to develop criteria for most if not all of the 129 priority pollutants. To date, only 24 water quality criteria have been promulgated. The slow rate of criteria development suggests that future efforts to promulgate sediment quality criteria will be no faster and probably will be limited to the same set of chemicals. Many of the 129 priority pollutants are no longer produced, and releases to the aquatic environment of those remaining have been significantly reduced.

Use of chemical-specific criteria for water was facilitated by the fact that chemicals in water are generally believed to be bioavailable. Further, there is a good theoretical basis for extrapolating laboratory toxicity data to effects in the field for a relatively simple, single-phase system. Chemical concentrations in water are readily measurable—or can be readily estimated from flow rates, dilution, and solubility parameters. Lastly, water is a relatively uniform media.

Estimations of sediment concentrations and biological effects are much more complex and difficult. When sorbed to sediments, chemicals are generally not thought to be bioavailable. Typically, if a chemical is found in sediment, it has greater affinity for sediment than water and only a small fraction is available for biological uptake. Predicting or measuring the amount that is bioavailable becomes the critical factor.

Even more problematic is accounting for the numerous factors involved in the liquid-solid phase interactions of water and sediments that may have significant impact on the fate, concentration, bioavailability, and toxicity of particular chemicals in different sediments. These factors (Table 2) reflect the realities that sediment is not a uniform media and that physical, chemical, physico-chemical, and site-specific properties may be important in overall evaluation of sediment quality. Since many of these factors and their interactions are only beginning to be investigated and understood, application of sediment quality criteria and national sediment standards in the near future to particular sites or regions is highly questionable.

Several methods are being developed to evaluate various aspects of sediment quality. The equilibrium partitioning approach for developing criteria is frequently cited as having the advantage that the existing water quality criteria can be directly converted to sediment criteria without further testing if the octanol–water (Kow) or sediment–water (Koc) partition coefficient is known for non-ionic chemicals (U.S. Environ. Prot. Agency, 1989a). This is shown in the following equation: WQC x Koc=SQC (oc). This provides a sediment

Table 2.—Factors affecting fate, concentration, and bioavailability of chemicals in sediments.

PROPERTIES	CHEMICAL FACTORS	SEDIMENT FACTORS
Physical properties	Solid, liquid, or gas and ionic state	Surface area Particle size Permeability Porosity Specific gravity
Chemical properties	Structure, chemical reactivity	Inorganic matrix Organic content Ion exchange capacity
Physico-chemical properties	Density Solubility Volatility Partition coefficient (adsorption/desorption) Dissociation constant Photolysis Hydrolysis	Temperature Oxygen content pH Redox potential Salinity
Other site- or region-specific considerations and properties	Discharge concentration Discharge volume Discharge pathway Discharge variability Discharge excursion history Sediment–chemical contact time	Sediment depth Sediment profile Sedimentation rate Sediment age Leaching rates Water flow rate variability Water currents Water exchange/transport Nutrient inputs Flow perturbation Biodegradation

quality criterion that is normalized for the organic carbon content of the sediment.

This method assumes that ecological systems are in equilibrium and kinetic rates of diffusion and transport are not limiting. It has also been primarily demonstrated for sediments with an organic content of 0.5 percent or more. Presently, it is unclear how well the EP approach for sediment criteria extrapolates to real world effect levels. The method assumes that interstitial water is the primary route of uptake for most sediment-dwelling organisms. Unfortunately, there has been no concerted effort to measure sediment interstitial water chemical concentrations in contaminated sediments to confirm that predicted sediment quality criteria values can be predicted using equilibrium partitioning theory. The method appears to be promising and may ultimately be validated but now should be primarily used as a screening level tool.

Other methods (U.S. Environ. Prot. Agency, 1990) for assessing sediments, such as the apparent effects threshold and sediment bioassay approaches, may also provide ways to develop sediment quality criteria, following additional development and field validation. Recently, both the Sediment Criteria Subcommittee of the Science Advisory Board (1989, 1990a,b) and Kimerle et al. (1991) have reviewed the advantages and limitations of these methods.

This discussion began by asking, should the water quality criteria approach be used to regulate chemical concentrations in our Nation's sediments? We believe the answer is no. The methodology is lengthy and costly and the potential number of criteria will be few and then mainly for chemicals, which are highly regulated already. Confidence in the scientific accuracy of the predicted sediment quality criteria will be low. Therefore, we present an alternative approach in the following section.

How Can We Better Assess Contaminated Sediments?

A wealth of experience has been obtained on environmental hazard assessment since a 1977 workshop at Pelleston, Michigan (Cairns et al. 1978) focused on chemical assessment. Many papers and books have been published on the subject of hazard and risk assessment techniques currently being used by EPA to regulate pesticides and toxic chemicals. The conceptual framework within most of the current approaches for assessing chemical hazards makes use of data on chemical exposure and biological effects on organisms. The collection and interpretation of these data are usually done in tiers that allow for periodic decisions to stop if adequate safety is demonstrated or toxicity is well characterized—or to collect more data if significant questions still remain. This approach has proven to be a robust paradigm for safety assessment that is cost effective and scientifically sound. We have used this conceptual framework to develop an approach for assessing the significance of chemicals sorbed to sediments (Fig. 1).

A sediment assessment would begin with Tier 1 using sediment assessment values (SAVs) that could be obtained in a number of ways. For instance, equilibrium partitioning theory could be used to develop SAVs for non-ionic organics by normalizing for sediment organic carbon, or potentially for metals by acid volatile sulfide normalization (DiToro et al. 1990), or for ionic organics by incorporating cation exchange capacity (DiToro et al. 1989). In addition, the apparent effects threshold (AET) method could be used to develop SAVs. Several other methods are in the developmental stage.

The Tier 1 SAVs would be used as screening level concentrations to be compared against environmental sediment concentrations. If the SAV is exceeded by the sediment concentration, then additional sediment assessment is required (Tier 2). If the value is not exceeded and the margin of safety is adequate (the ratio between the sediment field concentration and the SAV is $\geq$ 10), one would not conduct additional testing. Limited chronic aquatic toxicity testing and bioaccumulation estimation may be desired in some cases where the margin of safety is small (<10). If no SAV can be calculated for a particular chemical, then you would conduct Tier 1 screening toxicity tests.

Tier 2 is called an "investigative tier." In this part of the assessment, the determination is made whether or not the sediment contains chemicals in amounts toxic to aquatic organisms or if chemicals with a high potential to bioaccumulate are below levels of concern. Additional testing may be required to define the zone or magnitude of the area impacted by the chemicals in the sediments (PTI Environ. Serv. 1988).

It is proposed that the zone-of-impact study would include both chemical and biological measurements (Fig. 1). If the zone of impact is determined to be large, then additional testing would be required, with confirmatory tests (Tier 3). If the zone-of-impact is small, a decision could be made that no further action is required or to perform limited remediation.

Tier 3 is that part of the assessment approach that would provide in-depth testing of the sediments in the zone of impact to confirm the significance of the chemicals to aquatic life and their potential to move through the food web to other organisms.

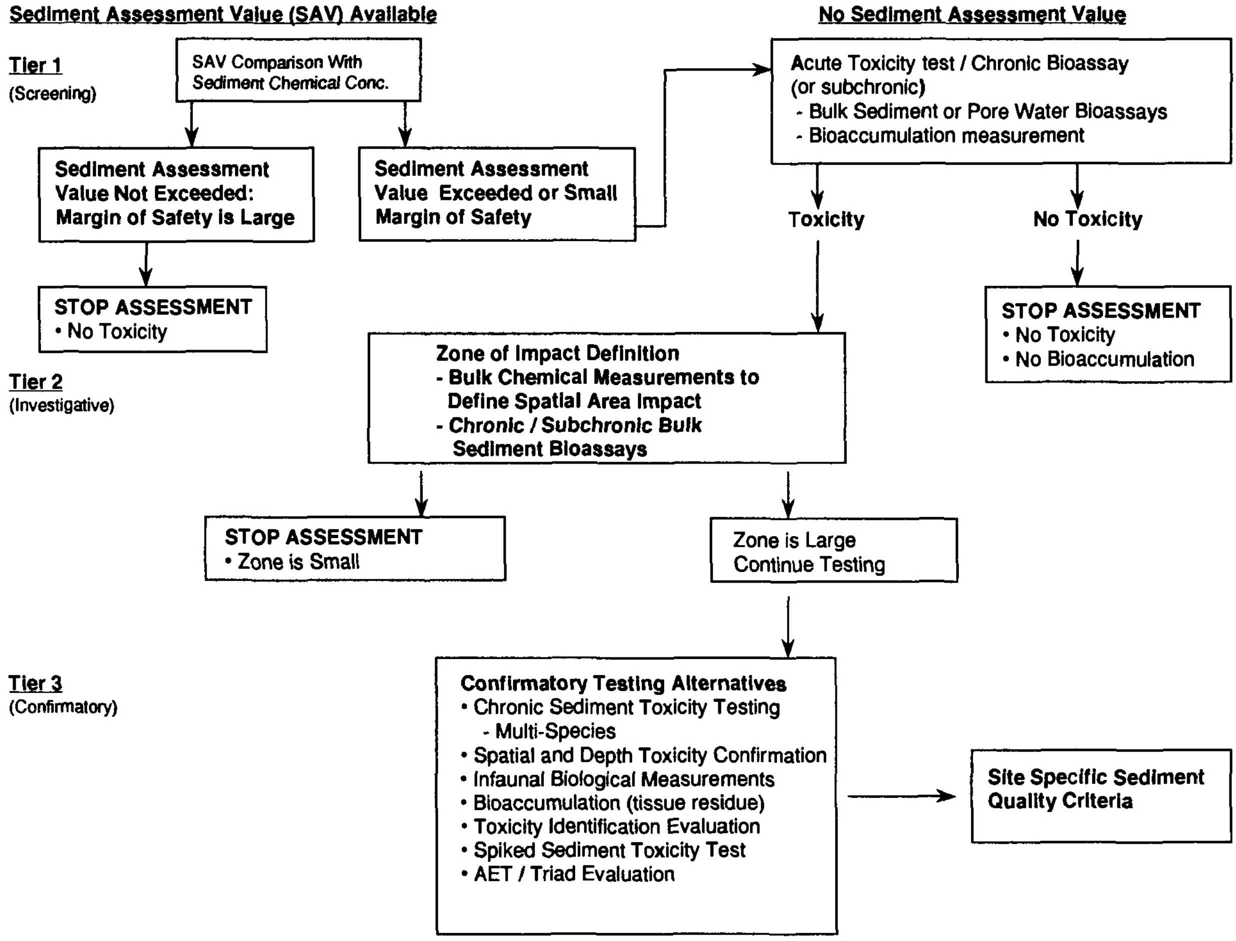

Figure 1.—Integrated biological and chemical field sediment assessment.

Multi-species chronic toxicity tests, spiked sediment bioassays, bioaccumulation measurements, and toxicity identification evaluations could be performed as well as infaunal investigation to determine impacts on the aquatic life in the zone of impact. Sufficient data might be collected to perform an apparent effect threshold evaluation and calculate a site-specific sediment quality criterion.

This integrated biological and chemical sediment assessment attempts to provide a comprehensive approach by using existing tools to evaluate the significance of chemicals on sediments without making use of inflexible criteria. The state of the art of assessing sediment contamination is not at the point where a single value can be generated and used to regulate end-of-the-pipe discharges or site cleanup levels. While this approach is not entirely novel and previous investigators have recommended the use of tiers for assessing sediments (Dickson, 1987), it does provide a comprehensive review of how existing methodologies can be used to assess and protect sediments. It is the authors' hope that this approach can be used to form the framework of a working approach that will be adopted by EPA.

Conclusion

As we look forward to the 21st century and begin making plans for further protecting aquatic resources, we must learn to develop strategies for evaluating, reducing, or containing sediment contamination. This is neither a simple nor an insurmountable task. What is needed is a clear understanding of our objectives, goals, and procedures. Rapid development of any one procedure or paradigm does not seem the wisest choice.

Since the passage of the Toxic Substance Control Act in 1976, the U.S. has evolved an elaborate set of regulations to control and use industrial chemicals and pesticides that has been guided by a general set of principles of hazard assessment (Cairns et al. 1978). This past approach can provide a valuable guide as we make plans to protect our sediments. Similarly, establishing scientific principles of sediment assessment can provide guidance for developing new sediment assessment tools for control and remediation of chemical releases. The principles presented in Table 3 are a first attempt to

Table 3.—Principles of sediment assessment.

- Many chemicals have an affinity for aquatic sediments, and past releases have resulted in contaminated aquatic sediments.
- Our long-term goal must be to protect the environment and keep excessive amounts of chemicals out of sediments.
- We must learn to assess the significance of sediment contamination and concentrate efforts on reduction and remediation of contamination in areas that have the highest potential to affect humans or the environment.
- Tiered sediment assessment provides a powerful tool for evaluating the significance of sediment contamination.
- Tiered sediment assessment allows integration of biological and chemical data.
- A stepwise comparison of sediment concentrations with biological effect concentrations through a series of tiers can form the basis for sediment assessment.
- Integrated biological and chemical sediment assessment procedures provide the opportunity to develop site-specific sediment quality criteria and, over the long term, develop the data needed to establish sediment quality criteria.
- Risk, benefit, and cost analyses should be an integral part of sediment quality assessment and any necessary remediation activity.

summarize a set of guiding principles for the 21st century.

There is no consensus within the scientific community on the best method for developing sediment quality criteria or whether such criteria are the best way to protect aquatic resources. Ocean and freshwater dumping regulations, sediment bioassays, and site-specific risk assessment methods are a few of the methods currently being used to control disposition and cleanup of contaminated sediments. Site-specific risk assessment methods may ultimately prove more useful than national criteria for decisionmaking.

Some States and the EPA want to develop criteria or regulatory levels for sediments before consensus is reached on the validity of these methods. We need to proceed carefully with well-considered science before any single method or group of methods is selected to develop sediment criteria. The need to develop sediment quality standards for end-of-the-pipe control and site cleanup standards are the primary reasons given for the urgency to develop criteria; however, it would be premature. No single method is developed enough to allow for defensible sediment quality criteria.

We believe that using sediment quality criteria is not the most effective way to control sediment chemical concentrations and protect the environment. However, an integrated biological and chemical risk assessment approach together with existing regulations and statutes offer a workable solution.

In this context, it is important to remember that most sediment contamination problems result from historic chemical discharges. The conditions that have allowed this to happen have, for the most part, been corrected though stricter discharge permits and by controlling and reporting spills and improving process controls. When water quality standards were instituted, they were envisioned as values that could be used to protect the environment from further damage. It was recognized that environmental concentrations were frequently higher in surface waters than the criteria that were derived, and it was perceived that using water quality criteria to derive effluent standards would be an effective and scientifically sound way to control concentrations of chemicals in point source discharges and, ultimately, the receiving water.

Unfortunately, the establishment of sediment quality standards will not produce the same results. Chemicals are already highly controlled at the point of discharge and further control will provide little environmental improvement. Development of sediment quality standards using existing methodologies will result in values that are much lower than currently exist in many of our waterways and coastal zones. Mandating implementation of these standards will not reduce environmental sediment chemical concentrations that have resulted from past releases, especially for persistent chemicals.

National remediation of aquatic environments on a broad scale to achieve sediment standards is not practical nor feasible. The impact of deriving criteria for point source control, remediation standards, and open water disposal of sediments with imprecise methods could have major economic consequences without appreciably reducing the risks to the environment. Therefore, the approach that is used to protect and improve sediments must be scientifically sound and cost effective, and must provide environmental and societal benefits.

EPA's Office of Water is reviewing how sediment criteria might be implemented under the Clean Water, Marine Resources, and Resource Conservation and Recovery acts, and Superfund (CERCLA). It would seem that this is an opportune time for scientists from government, academia, and industry to work together to develop a workable set of regulations. This type of relationship would be consistent with the goals set forth in the Clean Water Act and Office of Water 21st century goals document (U.S. Environ. Prot. Agency, 1989b).

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Assessing Contaminated Sediments

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Introduction

Sediment criteria are most useful for establishing a best judgment of contaminant levels below which no adverse effects resulting in a use impairment can be expected and above which an onset of use impairments should be expected. In other words, sediment criteria should have the same resource assessment objective as water quality standards.

However, since most contaminated sediment activities focus on in-place contaminants from past releases for management and purposes we must determine the level of sediment impairment, we must be able to use criteria to do more than just decide if a sediment is clean. If sediments are below criteria, then we don't have to do a thing but prevent further contamination. But what if criteria are exceeded? Can we expect significant use impairment just a bit above criteria? Do all sediments that exceed criteria have to be remediated? While these sorts of questions are also raised in water quality programs, answers are not often given or even expected since achievement of water quality standards is the single objective.

More will be expected from sediment criteria. Some sediments will not be remediated unless noticeable effects are expected when criteria are exceeded, and, for other sediments, not until effects become quite severe. Sediment criteria will have to be more than a single number representing a threshold of effects. There must be a series of higher numbers or a system for interpreting criteria that will enable users to predict the magnitude of effects at 10 times, 100 times, or even 1,000 times the criteria.

Also, until sediment criteria methods are considered as accurate as water quality criteria methods at hitting thresholds of effects, we will need some estimate of criteria variance. The U.S. Environmental Protection Agency (EPA) is doing this with its equilibrium partitioning criteria. Some guidance on figuring the implications of decisions at either end of the variance would also be helpful. For example, if we consider the upper 95 percent confidence limit for a criterion acceptable, what are the possible effects that are associated with that concentration?

Sediment Criteria Guidelines

Guidance for sediment criteria used in New York State by the Divisions of Marine Resources and Fish and Wildlife is not simply a list of numbers. It lays out a process by which staff can assess risk of contaminants in sediments at a particular site and make recommendations about remediation.

There are two types of criteria in the guidance: equilibrium partition criteria for non-polar organics and criteria for metals. There are 101 criteria for 53 individual non-polar organic chemicals and classes of chemicals. There are more criteria than chemicals because as few as one criterion exist for some and as many as six for others. Included are separate freshwater and saltwater criteria and individual criteria for three environmental protection objectives stipulating protection of:

- Aquatic life from the toxic effects of sediments,
- Human health, at the 1 in 1,000,000 cancer risk level, from consumption of fish and shellfish taken from waters with contaminated sediments, and

- Protection of wildlife from the toxic effects of consuming biota taken from waters with contaminated sediments.

All of the non-polar organic criteria were calculated as described in EPA's 1989 "Briefing Report to the EPA Science Advisory Board on the Equilibrium Partitioning Approach to Generating Sediment Quality Criteria" by multiplying water quality standards by the octanol/water partition coefficient and the organic carbon concentration in the sediment. Virtually every available water quality standard or criteria based on aquatic life use protection was used to calculate sediment criteria, including a number of water quality criteria that were generated just for use in developing sediment criteria.

After all these sediment criteria were calculated, one little quirk became apparent. For non-polar organics with a partition coefficient less than 100, the resultant sediment criteria are less than the water quality standards. To implement these low numbers is senseless, so until a better way to assess risk of low partition coefficient non-polar organics in sediments is developed, we have set their sediment criteria equal to their associated water quality standards criteria.

For metals, a different approach was taken. As everyone else, we are waiting for EPA to produce a list of metals sediment criteria or a method to calculate them, but until then are using some criteria derived from scientific literature on the effects of metals on benthic organisms in sediments.

The Ontario Ministry of the Environment contracted to develop sediment criteria by several alternative methods (Ont. Ministry Environ. 1988). The contractor's report contained results of the literature review on effects of metals in sediments. The Ontario Ministry of the Environment (Persaud, 1989) then derived from the contractor's report no-effect, lowest effect, and limits of tolerance levels for metals in sediments. The geometric mean of the no-effect and lowest effect levels was calculated to derive sediment criteria for metals for use in New York State. In addition, the contractor's report (Ont. Ministry Environ. 1988) contained upper 95 percent confidence limit values of preindustrial metal concentrations in Great Lakes sediments, which were considered reasonable estimates of background concentrations.

The result is that our guidance document contains sediment criteria for 10 metals, along with background, no-effect, lowest effect, and limits of tolerance concentrations for each. Staff reviewing sediment data for a specific site have a menu to select from to assess potential risk from the metals at that site.

Exceedance of sediment criteria can be expected to result in some specific adverse effects. The volume and location of sediment exceeding the criterion, the magnitude of the effect expected, the length of time sediments will be contaminated, and the certainty that the effect will occur will all play a role in making decisions about how much sediment to clean up to eliminate or minimize the adverse effects.

In consideration of these factors, a number of instructions have been developed, including the following:

1. Compare sediment concentrations with unimpacted, local background concentrations and consider the significance of criteria exceedances in light of background concentrations, in particular for naturally occurring substances such as metals. This caution is necessary because all of the metals criteria in the guidance are less than the upper 95 percent confidence limit of preindustrial metal concentrations in Great Lakes sediments. This can be interpreted to mean that, in some sediments, relatively low levels of metals, even below "high" background (the upper 95 percent concentration) are toxic, whereas in other sediments, fairly high levels (up to and possibly even above "high" background) may not be toxic.

2. For non-polar organic chemicals with partition coefficients less than 1000 that exceed criteria, neither further remedial investigation nor sediment remediation will be necessary if the State can demonstrate that the source of sediment contamination will be eliminated and the sediment will cleanse itself within one year. For these chemicals, documentation of a significant release that needs to be controlled may be the greatest value of sediment criteria.

3. For organics, exceedance of aquatic toxicity-based criteria by 100 times in significant portions of the ecosystem indicates a likelihood that biota are impaired and remediation would be necessary. The value of 100 is the product of the 10-fold uncertainty about the partition coefficients used to calculate the criteria multiplied by another factor of 10, which is a typical ratio between acute and chronic water quality criteria. In other words, at 100 times the sediment criteria, one would expect onset of acute toxicity.

For metals, if the limits of tolerance values are exceeded in significant portions of the ecosystem of concern, it is highly likely that biota are impaired and remediation should be considered necessary. The Ontario Ministry of the Environment now refers to the limits of tolerance as "severe effect levels." For all the metals (except iron), the limit of tolerance exceeds the 95 percent confidence limit "high" background, and at these levels, significant and noticeable toxicity would be expected in all sediments.

Options are also suggested in the guidance to conduct toxicity testing, residue analyses, or assessments of ecological communities to confirm impairment predictions based on criteria exceedances.

Conclusions

These criteria and associated guidance have been useful for developing staff positions on the need for remediation of contaminated sediments. If nothing else, the criteria have been very helpful as a screening tool, allowing the Divisions of Marine Resources and Fish and Wildlife to review the reams of data often generated for sediments at a site and state with some certainty that impairments are not likely when criteria are not exceeded. However, the divisions still need (and look forward to) national sediment criteria to lend support to our recommendations that any nationally accepted criteria can be expected to convey. In addition, national criteria should have associated guidance to enable users to interpret the significance of exceedances and aid in making decisions on when remediation is necessary and how much.

Finally, it appears from the various presentations given at this conference that a number of people with different backgrounds are arriving at similar methods for assessing contaminated sediments—which is probably a good sign. It shows that our ideas are crystallizing into a unified approach for dealing with contaminated sediments.

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WETLAND WATER QUALITY STANDARDS

Water Quality Standards for Wetlands

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Introduction

Over a year ago, I was asked to review the first draft of a publication on water quality standards on wetlands. My first reaction was extremely negative. I thought there were no water quality standards for wetlands and did not see a logical or theoretical basis for using existing surface water quality standards. Because of the temporal and spatial dynamics of wetlands, I scoffed at the idea of using numeric, chemical-specific, surface water standards (such as pH, turbidity, color, and hydrogen sulfide). Wetlands can have levels well above or below normal ranges for surface water and still be normal or even exceptional. Consequently, my comments were extensive and critical; hopefully, they were also constructive.

In July 1990, the U.S. Environmental Protection Agency's (EPA's) Office of Water Regulations and Standards' Office of Wetlands Protection published national guidance on water quality standards for wetlands (U.S. Environ. Prot. Agency, 1990). The following is a short summary taken from that document, which provides program guidance on how to ensure effective application of water quality standards to wetlands.

The basic requirements for applying water quality standards to wetlands include the following:

1. Include wetlands in the definition of "State waters."
2. Designate uses for all wetlands.
3. Adopt aesthetic narrative criteria (the "free forms") and appropriate numeric criteria for wetlands.
4. Adopt narrative biological criteria for wetlands.
5. Apply the State's antidegradation policy and implementation methods to wetlands.

Include Wetlands in the Definition of State Waters

The first, and most important step, is ensuring that wetlands are legally included in the scope of States' water quality standards programs. EPA expects the States to accomplish this by 1993; however, States may need to remove or modify regulatory language that explicitly or implicitly limits the authority of water quality standards over wetlands. States may choose to include riparian or floodplain ecosystems as a whole in the definition of "waters of the State" or to designate these areas for protection in their water quality standards.

Designate Uses for All Wetlands

At a minimum, all wetlands must have uses designated that meet the goals of section 101(a)(2) of the Clean Water Act by providing for the protection and propagation of fish, shellfish, and wildlife and for recreation in and on the water unless the results of a use attainability analysis show that the goals of that section cannot be achieved.

When designating uses for wetlands, States may choose to use their existing general and water-specific classification systems, or they may set up an entirely different system for wetlands reflecting unique functions. Wetland functions directly relate to the physical, chemical, and biological integrity of wetlands. Examples of wetland classifications, functions, values, and beneficial uses are provided in the national guidance.

Adopt Aesthetic Narrative and Appropriate Numeric Criteria

Narrative criteria are particularly important for wetlands because numeric criteria have not been fully developed. Narrative criteria should be written to protect the most sensitive designated use and to support existing uses under State antidegradation policies. Narrative biological criteria are general statements of attainable (or attained) conditions of biological integrity and water quality for a given use designation.

Narrative statements may prohibit certain actions or conditions ("free forms") or may be positive statements about what is expected to occur. They are used to identify impacts on designated uses and as a regulatory basis for controlling a variety of impacts to State waters.

Numeric criteria are specific numeric values for chemical constituents, physical parameters, or biological conditions that are adapted in State standards. Human health water quality criteria are based on the toxicity of a contaminant and the amount consumed through ingestion of water and fish regardless of the type of water. Therefore, EPA's chemical-specific human health criteria are directly applicable to wetlands.

EPA also develops chemical-specific numeric criteria recommendations to protect freshwater and saltwater aquatic life. The numeric aquatic life criteria, although not designated specifically for wetlands, were designed to be protective of aquatic life and are generally applicable to most wetland types. Numeric criteria are needed to protect the integrity of wetland functions, not only for aquatic and benthic organisms, but also vegetation and wildlife.

A note of caution: before existing chemical-specific numeric criteria are applied to wetlands, they must pass some logic checks. Can the standards be achieved by any wetlands? At what time of the year? Does the standard relate to protecting the designated use of the specific wetland type in a given location?

Adopt Narrative Biological Criteria for Wetlands

Narrative biological criteria are general statements of attainable or attained conditions of biological integrity and water quality for a given use designation. Narrative biological criteria can take a number of forms. The criteria could read "free from activities that would substantially impair the biological community as it naturally occurs due to physical, chemical, and hydrologic changes," or the criteria may contain positive statements about the biological community existing or attainable in wetlands.

Narrative biological criteria should contain attributes that support the goals of the Clean Water Act that provide for the protection and propagation of fish, shellfish, and wildlife. Since hydrology is the driving force behind the type and location of wetlands, maintaining their hydrology is critical to maintaining their health, functions, and values. Hydrologic manipulations occur in such forms as flow alterations (including any activity that results in impairing or reducing flow, circulation, or reach of water) and diversions, disposal of fill materials, ditches, canals, dikes, and levees.

Apply State's Antidegradation Policy

The antidegradation policies contained in all State water quality standards provide a powerful tool for the protection of wetlands and can be used to regulate point and nonpoint source discharges to wetlands the same as other surface waters. In conjunction with beneficial uses and narrative criteria, antidegradation can be used to deal with impacts to wetlands that cannot be fully addressed by chemical criteria, such as physical and hydrologic modifications.

With the inclusion of wetlands as "waters of the State," State antidegradation policies and their implementation methods will apply to wetlands in the same way as other surface waters. State antidegradation policies should provide for the protection of existing uses in wetlands and the level of water quality necessary to protect those uses in the same manner as provided for other surface waters. In the case of fills, EPA interprets protection of existing uses to be met if there is no significant degradation as defined according to the section 404(b)1 guidelines. State antidegradation policies also provide special protection for outstanding natural resource waters.

The national guidance document also has chapters on implementation and future direction. The appendices provide definitions of "waters of the U.S.," information on the assessment of wetland functions and values, and examples of State certification action including wetlands under section 401 of the Clean Water Act. Maybe most importantly, the national guidance provides the names, addresses, and phone numbers for the EPA Regional

Wetland Coordinators and U.S. Fish and Wildlife Service's National Wetlands Inventories' regional wetland coordinators.

The Fish and Wildlife Service's National Wetlands Inventory has produced over 30,000 detailed wetland maps, which cover 70 percent of the conterminous United States, 22 percent of Alaska, and all of Hawaii. Wetland maps are complete for 21 States; mapping is ongoing in the remaining 28 States (wetland mapping has not been initiated in Wisconsin). Total dissemination reached one million wetland maps in June 1990.

Copies of the maps are sold through the toll-free number, 1-800-USA-MAPS; in Virginia at (703) 684-6045; and through 27 state-run distribution centers.

The U.S. Fish and Wildlife Service, in cooperation with the States, has computerized (digitized) more than 6,916 of its wetland maps, representing 12.8 percent of the continental United States. Statewide digital databases have been built for New Jersey, Delaware, Illinois, Maryland, Washington and Indiana and are in progress for Virginia, Minnesota, and South Dakota. National Wetlands Inventory digital data are also available for portions of 25 other States.

The report entitled "Wetlands Losses in the United States: 1780's to 1980's," which has been completed and sent to Congress, presents wetland acreage and losses by State. Copies of the report can be obtained by writing the U.S. Fish and Wildlife Service's publications unit at Room 130, Arlington Square, 1849 C Street, NW, Washington, D.C. 20240 or calling the Agency at (703) 358-1711.

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U.S. Environmental Protection Agency. 1990. National Guidance: Water Quality Standards for Wetlands. Off. Water Reg. Stand., Off. Wetlands Prot., Washington, DC.

Water Quality Standards for Wetlands in Tennessee

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Introduction

In the late 1600s, there were over 200 million acres of wetlands in the lower 48 States; today, less than half—95 million acres—still exist. From 1950 to 1980, over 11 million acres—an area more than two times the size of New Jersey—were lost (U.S. Environ. Prot. Agency, 1988a).

In Tennessee, where an estimated 3 million acres of wetlands once existed, the State's Department of Conservation estimates between 500,000 and 800,000 acres remain (Tenn. Dep. Conserv. 1987), while national wetlands inventory maps show Tennessee's wetlands at 787,000 acres or about 3 percent of the State's land area (Wilen, 1989). All of this information translates into a loss of approximately 75 percent of Tennessee's wetlands over the last 60 years.

About 571,000 wetland acres (almost three-fourths of the existing acreage) are found in west Tennessee, which is one of the most suitable regions for agriculture (Smith et al. 1987). A major challenge that Tennessee and other States continue to face is the need to develop ways to permit or mitigate wetlands in a no net loss to the resource fashion and, at the same time, allow continued and often increased agricultural production.

Over the last few years, Federal, State, local, and other citizen and environmental entities have been working together in Tennessee to resolve and/or mitigate conflicts over wetlands issues. The Natural Resources Section of the Tennessee Division of Water Pollution Control must continue to explore workable suggestions and responses to why water quality standards are needed for wetlands. The U.S. Environmental Protection Agency's (EPA's) wetland protection backgrounder lists the following benefits derived from wetlands (U.S. Environ. Prot. Agency, 1988b):

- **Physical Protection:** Wetlands protect shorelines from erosion by dissipating wave or storm energy and downstream areas from damaging flood flows by slowing and temporarily storing floodwaters, thus reducing peak flows.
- **Water Quality Enhancement:** Wetlands remove pollution from waters that flow through them by physical adsorption to plants or bottom sediments, chemical precipitation, or biochemical breakdown or uptake. In effect, they function as biological sewage treatment plants.
- **Groundwater Recharge:** In some areas, wetlands serve as groundwater recharge zones for underlying or adjacent aquifers. Many areas store water during the wetter parts of the year and release it at relatively constant rates, helping to maintain regular stream flows.
- **Wildlife Habitat:** Wetlands provide critical breeding, nesting, rearing, and wintering habitat for many species of fish and wildlife. Forty-five percent of federally listed threatened or endangered animals

and 26 percent of such plants depend directly or indirectly on wetlands to complete their life cycle successfully.

■ **Food Chain Support:** Coastal and riverine wetlands produce large quantities of plant-derived food that are exported to estuaries and other coastal areas where they support marine ecosystems, many of which are critical to commercial fisheries.

■ **Commercial Products:** Wetlands are a habitat for fish, shellfish, furbearers, timber, forage, wild rice, cranberries, blueberries, and other useful materials. Over $10 billion annually is spent on nature study, fishing, hunting, and other outdoor activities in wetlands.

■ **Recreation and Aesthetics:** Wetlands provide places to hunt, fish, study nature, photograph, canoe, and receive outdoor education. Wetlands are also coming to be viewed as valuable simply for their natural beauty.

■ **Climatic Influences:** Wetlands play an important role in global cycles of nitrogen, sulfur, methane, and carbon dioxide. They may help control atmospheric pollution by removing excess nitrogen and carbon produced through human activities.

According to EPA's Office of Wetlands Protection, the first step in developing water quality standards for wetlands is to include these areas in the State's definition of waters. Tennessee is one of 30 States that do not specifically mention wetlands in State water quality standards (U.S. Environ. Prot. Agency, 1989a). Although Tennessee has not formally defined the term "wetlands" in its water quality standards, the State regulates and protects these areas through the section 401 certification program, which is administered by the Natural Resources Section of Tennessee's Division of Water Pollution Control, and a strong State water quality act.

The promulgation of section 401 and other wetlands-specific regulations is underway, with the division's goal to have these additional regulations in place by spring of 1991. In the absence of regulations, a liberal interpretation of the Tennessee Water Quality Control Act of 1977 (Tenn. Dep. Health Environ. 1988) and the intent of a gubernatorial executive order for the protection of wetlands is used for program guidance. The executive order directs that uses of wetlands—including surface water supply, floodwater storage, purification of surface and groundwater, plant and animal habitat, recreation, and aesthetic uses—be "protected against unnecessary despoliation."

In the governor's executive order, wetlands are defined as areas that have hydric soils and a dominance (defined as a 50 percent stem count) of obligate hydrophytes ("plants that occur almost always in wetlands under natural conditions" [Train. Inst., Inc. 1989]). The executive order specifically includes "freshwater meadows, shallow freshwater marshes, shrub swamps with semi-permanent water regimes most of the year, and wooded swamps and bogs." In addition, an area with only one of two factors (hydric soils or obligate hydrophytes) can be defined as a wetland after it is evaluated by State agencies. However, the executive order also contains unclear language that exempts farmland inundated by "improper river channel maintenance."

Tennessee has relied on broad prohibitory language in its water quality standards to deny water quality certification for wetland fill projects. This ruling was upheld in court in a suit, *Hollis* versus *Tennessee Water Quality Control Board,* that was brought by an applicant who proposed to dump fill along the southeastern shoreline of Tennessee's only natural swamp lake, Reelfoot Lake (Chancery Court, 1984).

In the ruling, two important considerations were upheld concerning the relationship of wetlands permitting to the State's Water Quality Control Act: that Reelfoot Lake and the wetlands adjoining it are "waters of the State" and that a permit was required to discharge fill material under the Water Control Act. (Therefore, Hollis was in violation of permitting requirements.)

The following Tennessee Water Quality Act definition strengthens the concept that wetlands are waters of the State:

> "Waters" means any and all water, public or private, on or beneath the surface of the ground, which are contained within, flow through, or border upon Tennessee or any portion thereof except those bodies of water confined to and retained within the limits of private property in single ownership which do not combine or effect a junction with natural surface or underground waters. [Acts 1971, ch. 164 § 3; 1977, ch. 366, § 1; T.C.A, § 70-326; Acts 1984, ch. 804, § 1; 1987, ch. 111, § 1.] (Tenn. Dep. Health Environ. 1988).

However, Tennessee's definition of waters does not specifically mention wetlands, as the Federal definition does (40 CFR section 232.2 (q)): "(2) All interstate waters including interstate wetlands;. . ."

Therefore, Tennessee should consider adding specific similar language to further define wetlands as "waters of the State" in its water quality standards.

The Tennessee Water Quality Control Act's definition of pollution has also helped clarify wetlands permitting issues. According to the act, the commissioner cannot issue a permit for an activity that would cause pollution either by itself or in combination with other activities. The act defines pollution as follows:

> (22) "Pollution" means such alteration of the physical, chemical, biological, bacteriological, or radiological properties of the waters of this state including but not limited to changes in temperature, taste, color, turbidity, or odor of the waters:
>
> (A) As will result or will likely result in harm, potential harm, or detriment to the public health, safety, or welfare;
>
> (B) As will result or will likely result in harm, potential harm, or detriment to the health of animals, birds, fish, or aquatic life;
>
> (C) As will render or will likely render the waters substantially less useful for domestic, municipal, industrial, agricultural, recreational, or other reasonable uses; or
>
> (D) As will leave or will likely leave the waters in such condition as to violate any standards of water quality established by the board: (Tenn. Dep. Health Environ. 1988).

Under (22) (B), the phrase "detriment to the health of animals, birds, fish, or aquatic life" has been applied in cases to protect wetlands.

In 1988, 44 of all 401 certification requests were denied and some form of mitigation was required on the remaining 56 percent. The Natural Resources Section of the Division of Water Pollution Control has been issuing permits and making permit decisions but has not been enforcing permit-related cases effectively. State water quality standards for wetlands would strengthen the division's enforcement capabilities.

Wisconsin is proposing to protect a range of wetland functional values (including stormwater and floodwater storage, hydrologic functions, filtration or storage of sediments, shoreline protection against erosion, and water quality and quantity support for aquatic organisms) with the following narrative language in its draft water quality standards:

NR 103.04 Wetland Water Quality Standards

> (1) To preserve and enhance the quality of waters in wetlands and other waters of the state influenced by wetlands, the department shall protect the following water quality related functional values of wetlands, within the range of natural variation: . . . .

Tennessee is proposing to follow Wisconsin's lead through the State's permit regulations under 1200-4-7.03(4)(c)1-3;(f)1-7 by protecting the same wetland functional values through permitting regulations as follows:

1200-4-7.03 Permits

> (4) Terms and Conditions of Permits.
> (c) No permits shall be issued for activities which will or will likely result in any of the following:
>
> 1. a net loss of wetland functions;
> 2. a violation of Chapter 1200-4-3; or,
> 3. pollution as defined by the Act.
>
> (f) Permits issued for wetland alterations shall be conditioned to protect the following wetland functions . . . .

States must begin to consider the minimum EPA requirements for wetland water quality standards for fiscal year 1993, as issued in a recent national guidance document (U.S. Environ. Prot. Agency, 1990):

FY 1993 Minimum Requirements for State Water Quality Standards for Wetlands—EPA Guidance

- Include wetlands in the definition of State waters.
- Designate uses or establish beneficial uses for all wetlands.
- Adopt existing narrative ("free froms") and appropriate numeric criteria for wetlands.
- Adopt narrative biological criteria for wetlands.
- Apply the State's antidegradation policy and implementation methods to wetlands.

To meet these requirements, Tennessee's Natural Resources Section proposed the following additional narrative regulations for the State's water quality standards, as well as 401 permit related regulations, which were presented at a public rulemaking hearing January 10, 1991.

Draft Proposal

Add new language to 1200-4-3, General Water Quality Criteria as follows:

1200-4-3.02 General Considerations.

> (9)Waters designated as swamped out bottomland hardwoods or swamped out cropland shall be protective of wildlife and humans that may come in contact with them but shall not be classified for the protection of fish and aquatic life.

1200-4-3.04 Definitions.

> (3) Swamped out bottomland hardwoods means those areas where living bottomland timber is subject to stress due to ponded water and areas of dead timber. Swamped out bottomland hardwoods shall not include areas with a dominance of cypress or tupelo gum or areas in

which the majority of the timber died prior to 1977.

(4) Swamped out cropland means those areas which were previously in row crops but cannot now be cultivated due to ponded water. Swamped out cropland shall not include wetland areas which have reverted from cropland prior to 1977.

At the public hearing, there was widespread opposition from both the environmental and regulatory communities to various sections of these proposed rules. The Division of Water Pollution Control, the Tennessee Farm Bureau, and other concerned agencies have held several meetings and hours of discussion over this draft proposal. Following a 30-day comment period, the Division of Water Pollution Control will consider having another public rulemaking hearing. The revised regulations will then be submitted to the State's water quality board.

The division continues to refine its antidegradation policy, especially as it relates to wetlands protection. The Natural Resources Section has used the current antidegradation statement frequently in denials of 401 certification and has been successful through a liberal interpretation of the phrase "waters of exceptional recreational or ecological significance." Projects have been denied on State scenic rivers, on streams that serve as critical habitat for endangered species, and on streams and wetlands whose overall quality was exceptionally ecologically significant.

The antidegradation policy was the primary factor in denying the Tuscumbia River Project, which would have channelized 7.4 miles of that river, a major tributary of the Hatchie River, which is a State scenic river and the only unchannelized Mississippi River tributary in Tennessee. It was determined that the Hatchie River would be adversely affected by this U.S. Army Corps of Engineers project and the wetlands of the Tuscumbia River were waters of outstanding ecological significance. However, Tennessee's policy on determining consistency with the antidegradation statement for all wetland projects still needs to be clarified.

Some States have developed a list of outstanding national resource waters that, when wetlands are included, has helped to regulate and protect these areas more effectively. However, attempts to produce a list of these waters for Tennessee, which has meant developing a consensus among various agencies and entities as to which waters of the State should be included, has proved to be politically infeasible. However, it is an option that many States may want to explore.

In Tennessee's 1987 water quality standards, 10 numeric criteria were established for domestic water supply (Tenn. Dep. Health Environ. 1987). The division is currently proposing numeric criteria for 86 toxic pollutants in Tennessee's 1990 water quality standards that fall under three categories: 18 for domestic water supply, 31 for freshwater fish and aquatic life, and 70 for human health and recreation. The addition of these numeric criteria has served as a major stumbling block in the attempt to expedite promulgation of these water quality standards. A similar fate is anticipated for numeric criteria and narrative biological criteria for wetlands. A database for biocriteria must be developed before Tennessee can set narrative or numeric biological criteria.

A major impetus for promulgation of water quality standards, however, will be the establishment of national numeric criteria in 1991 for States that have failed to comply with 303(c)(2)(B) (Fed. Register, 1990).

3312. Water Quality Standards for Toxic Pollutants

Abstract: This action may establish on a national basis, numeric water quality criteria for toxic pollutants that will become part of the water quality standards of states that have failed to comply with Sections 303 (c) (2) (B) of the CWA [Clean Water Act], thus, bringing those standards into compliance with the CWA, as amended.

Tennessee's water quality standards can serve as the driving force and guidance in many of the Division of Water Pollution Control's activities. Water quality assessment and standards affect nearly all of the division's other major programs, including municipal and industrial wastewater, aquatic resource protection, enforcement and compliance, and nonpoint source control. Developing a workable set of water quality standards for wetlands that can be promulgated in a reasonable amount of time is therefore vitally important to any State water pollution agency. The narrative approach for developing water quality standards for wetlands is, at this point, the preferred alternative in Tennessee simply because narrative language probably can be implemented quicker and used more effectively.

Lack of funding is a major factor that will continue to affect the division's efforts. The Natural Resources staff has been reduced from 10 to 6, and the division has lost 20 technical positions over the last five years. In 1990, the Natural Resources Section issued over 400 permits: 145 for Corps of Engineers-related 404 projects, 170 for aquatic resource alteration projects, and 100 for gravel dredging projects. These numbers translate into 69 permits per staff person, annually. Tennessee is proposing a fee-based permitting system as an option to remedy this problem. However, over $2 million must be generated annually to fund the new staff needed to accomplish these goals.

Conclusions

Tennessee should develop water quality standards for wetlands because:

- Wetlands are beneficial areas.
- Federal requirements mandate State action.
- Standards help States protect a dwindling resource.
- The State permitting process is made easier because enforcement is strengthened.

The Division of Water Pollution Control's Natural Resources Section has been successful in issuing 401 certification for 404 dredge and fill projects but has not been as successful in enforcing certain permits related to these projects.

Wetlands can and have been incorporated into the definition of State waters. However, adopting numeric criteria and narrative biological criteria for wetlands may pose difficulties similar to those encountered with several of Tennessee's proposed numeric criteria for toxic pollutants.

Tennessee should develop a database for biocriteria and a list of outstanding national resource waters to protect wetlands. Tennessees's proposed antidegradation statement can and has been applied to the 401 certification process to protect wetlands.

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Wetland Water Quality Standards

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Introduction

The Forest Service manages wetland and riparian areas following principles of wise use. A primary focus is maintenance of water quality to support downstream beneficial uses and sustain wetland ecosystems. The Forest Service believes that water quality criteria developed for wetlands should focus on those additional criteria necessary to protect the water component of these vital ecosystems.

This agency's experience is with nonpoint source issues, since most National Forest System lands lie at the headwaters of drainages; therefore, it has not had to deal with many major point source pollution issues. This is not the case for other Federal land managers of wetlands that face serious threats from upstream water quality problems. The Forest Service's experience does provide some overall perspectives on narrative criteria, however, particularly as they relate to nonpoint sources.

Standing water ecosystems usually require a different standard of protection because of pollutant accumulation and lengthy retention times. Wetlands are unique in being located at the lower end of the watershed and thus cumulatively reflecting what is happening in tributaries. This relationship should be recognized in addressing numerical criteria for upstream segments. In many cases, important wetlands may be the key designated use that needs protection.

Time-delayed Impacts

Setting numeric criteria to provide adequate protection can be a challenge. For one thing, the cause and effect relationship between pollutant and beneficial use may be so widely separated in time that numeric criteria alone will not provide adequate protection. Lick Creek in Idaho provides an example of delayed and cumulative impacts (Schmidt and DeBano, 1990).

In the late 1940s, the small headwater tributaries of Lick Creek were the scene of a logging operation. In the early 1970s, catastrophic erosion of wet meadows occurred, the result of ignorance 30 years earlier about the importance of altering channel systems. A small channel, which had been accidentally diverted down a skid road during the logging, generated sediment that was moved downstream and created additional erosion. When the sediment eventually reached a culvert at a critical road crossing, it accumulated and blocked the area, diverting the high stream flow down the road. Thus, sediment produced years ago at a point high in the watershed ultimately caused major erosion and damage.

The key points of this example are:

- It was 30 years until a significant water quality impact was noted.
- It is unlikely that current water quality criteria, especially turbidity, would have detected the problem.
- Hindsight shows the importance of designing and applying best management practices (BMPs) to prevent problems rather than relying on water quality standards.

Developing criteria for wetland hydrology and streamside riparian areas may prove to be important in protecting proper function; however, identifying what to protect will be a challenge.

Hydrologic and Geomorphic Criteria

Turbidity measurements are of little value as measures of water quality in bedload sediment-dominated stream systems. Rosgen and Leopold (1990) have demonstrated that accelerated channel erosion problems usually are caused when some disruption affects a stream's ability to move the naturally occurring supply of sediment. Bedload material is particularly important, especially excess amounts from disturbances that lack proper conservation measures or BMPs.

Channel characteristics, including width versus depth ratio, sinuosity, and bankfull flow, are vital in understanding stable channel conditions and in developing successful restoration projects. These and similar factors for each stream type should be considered in developing hydrology criteria for riparian wetlands.

By contrast, some approaches that specify a no activity zone for 100 feet on either side of a waterbody often fail to serve water quality or wise use of wetland resources. This approach is overly simplistic and neglects the principles, origins, and pathways of pollution. Wisely applied measures based on science and technology are needed rather than a rigid cookie-cutter approach to applying restrictive criteria, because such fixed limits are often excessive in areas of little threat and deficient where greater threats exist.

A specific purpose should be identified for such buffers and criteria developed to make the no activity zone serve its function. For example, a buffer of trees that regulates water temperature by shading the stream course functions differently than a soil erosion buffer, created by placing woody residue from forestry operations on the land surface to filter sediment from overland runoff.

Best Management Practices

Use of water quality standards as a management technique to control impacts of land use activities can only provide after-the-fact information. These data, however, are valuable and necessary in determining the effectiveness of management programs, including BMPs. Defining BMPs is key to preventing problems from occurring in the first place. For nonpoint sources, this is particularly important because it is usually not possible to rapidly terminate the discharge after a water quality problem is discovered.

If prevention is the goal, then BMPs must serve as the performance standard for land managers, and properly defined water quality standards can be used to assess the effectiveness of required BMPs. When monitoring indicates a problem with specific BMPs, mitigation should correct it to the extent possible and change future design criteria so the problem will not reoccur.

Many nonpoint impacts to riparian and wetland systems can be substantially controlled by BMPs, especially if they focus on particular problems. Some people who are disappointed and frustrated with BMPs feel the answer is greater emphasis on numeric criteria. Our reviews give a slightly different picture. We find that BMPs are effective, but:

- They must be integral considerations in project planning, not afterthoughts,
- Applications must be timely,
- The prescription must be followed completely,
- Follow-up actions to fix or supplement BMPs should be taken as necessary, and
- All activities in a basin should conform to the required standard of performance.

A successful application of BMPs is not just a concept. Before establishing additional numeric criteria, States should insist that landowners deliver on promised BMPs.

A Water Quality Focus

Focus on water quality when dealing with wetlands, but do not expect to resolve all wetlands issues through this parameter. Issues that are not directly water quality-related should be dealt with in a separate forum. The pitfalls can be best illustrated by a recent Forest Service project to restore wetlands where preference rather than clearly necessary criteria were applied, nearly defeating a beneficial wetlands restoration project (Rector, 1990).

In 1976, the Forest Service exchanged 1,970 acres for 17,800 acres that contained potential wetlands and developed a plan to restore wetland values. These rangeland acres had been wetlands prior to being drained in the early 1900s. In the 1980s, the Forest Service began restoring these areas by seasonally rewetting 890 hectares (2,200 acres).

In 1990, 17.2 hectares (43 acres) of nesting islands were designed and a contract let for their construction during the dry season.

These nesting islands enhanced the value of the wetlands. There was no decrease in the wetland water volumes because the islands were constructed from wetland sediments from the former lake bed.

However, the Army Corps of Engineers determined that these were "waters of the United States" and required a permit. In addition, the Fish and Wildlife Service consultation suggested that:

- Mitigation was needed for 43 acres of the islands,
- The islands were too symmetrical and uniformly distributed, and
- Riprap was not acceptable as protection against nesting island erosion, despite an identified need based on experience with previous restoration.

The Forest Service temporarily suspended the project and may have to pay penalties to the contractor. The concerns causing the delay focused on esthetics, riprap, and mitigation. There was no water quality purpose or beneficial use protection served in nearly defeating this wetland improvement project, yet water quality concerns provided the basis for the applied criteria. Fortunately, the Corps of Engineers recognized the importance of the project and expedited the permit process, avoiding the potential loss of project funding (Smith, 1991).

Artificial Wetlands

The Forest Service is using artificial wetlands to reduce metals from acid mine drainage in Kentucky and municipal effluent to support a new wetland in Arizona. The current National Guidance on Water Quality Standards for Wetlands, issued July 1990 (U.S. Environ. Prot. Agency, 1990), recognized that these areas should not be considered waters of the United States for regulatory purposes.

Other existing incidental wetlands, such as those associated with stock ponds, farm ponds, and small irrigation ditches, also should not be subject to regulation as waters of the United States. There are more important issues in protecting wetland water quality. Regulating these waters as wetlands might alienate people who would otherwise support important water quality controls to protect wetlands.

There is an increasing need for water to support quality wetland and riparian ecosystems. Most of the available water has already been allocated through State authorizations or court adjudications. Agencies restoring wetlands or riparian areas will have to determine the amount and timing of water needed to sustain the function and value of these areas. Necessary water must be acquired through State procedures or by lease or purchase of existing water rights. Failure to provide the necessary water can undermine wetland improvements.

Conclusions

- Wetlands should be recognized as a beneficial use to be protected.
- Water from tributary segments must be of sufficient quality to meet the needs of downstream wetland beneficial uses.
- Artificial wetlands for treating water quality should continue to be exempt. This exemption should be expanded to existing stock ponds and similar small incidental wetlands that exist only as a result of human activities.
- Hydrology criteria for the physical landscape (geomorphology), flow regimes, and water availability must be addressed.
- Best management practices need emphasis and follow-up. One size fits all, cookie-cutter restrictions should be avoided in efforts to protect wetlands.
- Water quality criteria should not be used to solve wetland habitat and aesthetic concerns.

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Criteria to Protect Wetland Ecological Integrity

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Introduction

Wetlands are complex ecological systems that range from riverine and lacustrine wetlands associated with rivers and lakes, respectively, to isolated wet meadows. Most are covered with surface water during part of the year; others are flooded for a short time, with varying periods of soil saturation. Wetlands, which frequently occupy depressions in the landscape where surface and ground waters accumulate, are readily polluted by a variety of anthropogenic sources.

A minor element in EPA's water quality regulatory frame, wetlands' importance as regulated waterbodies will expand after 1993, following their mandatory inclusion into "Waters of the States" (U.S. Environ. Prot. Agency, 1990). Historically, wetlands have been regulated under section 404 of the Clean Water Act, and although water quality is an issue in 404 decisions, it has not been the driving variable. The no net loss of wetland area and function as proposed by the Conservation Foundation (1988) and advocated by the president will also affect wetland regulations.

The goal of regulation is to protect wetland ecological integrity. (Figure 1 is a simplified diagram that illustrates this relationship.) The ultimate management objective is to achieve a state of ecological integrity, an acceptable condition of wetland health—the central circle in Figure 1. The middle circle represents factors that define ecological integrity. In a healthy wetland, these factors are at some level of collective acceptability. The outer ring represents stressors that affect elements in the middle ring. Ecological integrity is threatened when one stressor (or any combination) impedes the wetland's capacity to maintain a healthy condition.

This presentation is based on the premise that a range of criteria are necessary to protect wetland ecological integrity from a variety of stressors.

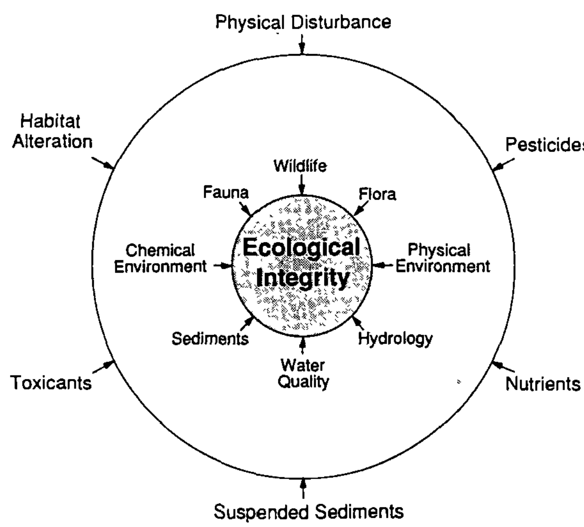

Figure 1.—A simplified diagram relating environmental stressors, wetland biogeochemical characteristics, and ecological integrity.

Protective Criteria for Wetlands

Biological Criteria

Biological criteria are a necessary part of wetland standards and criteria development. Existing aquatic life numeric criteria protect wetlands from specific contaminants, while biological criteria assess wetland biological conditions — they are the measures of regulatory success. Biological criteria also offer techniques to quantify effects of disturbance other than traditional contaminants, such as habitat alteration.

Biological criteria are being developed for surface waters and are included in several States' water quality standards. The approach used will likely follow that for other surface waters. Simplified, it usually includes:

- Wetland classification,
- Selection of reference sites based on spatial considerations and/or wetland types,
- Collection of biological data from the reference wetlands,
- Development of biological measures to analyze the reference sites, and
- Assignment of a range of acceptability to the biological measures.

However, distribution of wetlands and their relationship to the landscape are not as clearly defined as for other surface waters. Wetland macroinvertebrates and fish communities are less well documented. Extensive research will be required to develop community standards that use these organisms. Since wetlands are frequently dominated by vegetation, biological criteria should also include vegetative characteristics.

In addition, biological criteria can be developed for specific functional processes. For example, nitrification and denitrification rates may provide a means to estimate the health of the microbiota, which could be related to general wetland health. Bird indices can provide measures to integrate trophic levels for wetlands similar to fish community structure and trophic information for surface waters. Biological criteria will be necessary to protect habitats and biological diversity.

More research should be done to:

- Classify wetlands to determine reference sites,
- Assess biological diversity of reference sites,
- Develop biological measures of ecological integrity, and
- Test biological criteria over a range of wetland types.

Aquatic Life Criteria

The existing aquatic life numeric criteria are the primary surface water effluent regulatory tools. Generally chemical-specific, they are derived using specific test protocols (Stephan et al. 1985). Questions have been raised on the applicability of these criteria to wetlands because of some important physical, chemical, and biological characteristics that differ between wetlands and many other surface waters. Differences that have caused concern include a wider pH range, higher organic carbon content, water level fluctuations ranging from flooded to dry, a different faunal composition, and a biomass dominated by higher plants.

Because of the complexity of deriving numeric criteria and the differences in quality between many surface waters and wetlands, numeric criteria must be carefully evaluated and not indiscriminately applied to wetlands. An initial evaluation of numeric criteria application to wetlands was done at the Environmental Research Laboratory–Duluth (Minnesota) by Hagley and Taylor (1990), who concluded that numeric criteria are probably protective of most wetland types with standing surface waters. Their determination is based primarily on the method used to derive numeric criteria. The testing is designed to maximize toxicity to the test organisms, and the tests create conditions where toxicity is most likely to be expressed.

Many of the physical and chemical conditions present in the wetlands would likely reduce the predicted toxicity, as determined by the laboratory bioassays. For example, the high dissolved carbon content in wetland waters would likely reduce the toxicity of many nonpolar organic substances. Where there are questions on the application of the existing numeric criteria, existing site-specific guidelines may provide options to adjust them. These adjustments may be as simple as using organisms common to wetlands in the criteria development data set or may (in an extreme case) involve a complete toxicological analysis and development of new numeric criteria specific to wetlands.

Whole effluent toxicity testing protocols that are also being used to regulate surface water quality could be extended to wetlands. This procedure employs a standard toxicity test to assess effluent quality. An additional tool is the toxicity identification evaluation (TIE), a tiered approach to identifying classes of toxicants. However, before effluent testing and TIE can be applied, they will have to be tested using physical and chemical conditions typical of wetlands.

More research should be done to:

- Evaluate existing aquatic life numeric criteria to determine their level of protection for wetlands,
- Determine through toxicological testing, if the exposure, duration, and effects of toxicants on wetland organisms are similar to those of surface water organisms, and
- Develop toxicological testing protocols specific to wetland macrophytic vegetation.

Hydrologic Criteria

There are no surface water criteria for the protection of wetland hydrology. Yet, in terms of actual impacts, hydrologic change is the agent most responsible for ecological damage. Both insufficient and excess water should be considered when determining hydrologic criteria. With either condition, major wetlands changes will occur. Similarly, it is important to consider the hydroperiod because variations can produce serious structural and functional impacts. Hydrology is complex to monitor because both surface and ground waters must be measured continuously. However, techniques are being developed that relate long-term hydrologic measures and U.S. Geological Survey river sampling data to surface water and groundwater monitoring sites.

Because the knowledge and/or tools to develop hydrologic criteria are only just being developed, it will be necessary to regulate hydrology through a narrative criteria framework at first.

More research should be done to:

- Develop a theoretical basis for hydrologic criteria,
- Develop relationships between hydrology and wetland structural and functional integrity,
- Develop relationships between hydrology and the effects of other anthropogenic inputs (agricultural chemical runoff), and
- Develop indicators to assess the hydrologic state of a wetland.

Sediment Criteria

Both wetland sediment quality and quantity must be managed. Excess sedimentation can modify wetland hydrology. Also, it is necessary to determine if a sediment is likely to be toxic and therefore affect organisms for whom it is a normal habitat or through sediment manipulation, such as dredge and fill activities.

Sediment toxicity criteria differ somewhat from traditional, surface water, numeric aquatic life criteria because they are being developed for classes of contaminants and sediment types rather than specific chemicals. An example of this approach is the following: Acid volatile sulfide (AVS) (Di Toro et al. 1991) concentration in sediment is related to the capacity of the sediment to retain heavy metals. With increasing AVS, sediments can retain additional heavy metals. Thus, it is possible to determine sediment carrying capacity for heavy metals and assess whether this capacity is being exceeded.

AVS analysis also includes a toxicity identification component similar to whole effluent testing procedure's TIE. Where significantly different redox conditions exist, similar relationships in wetlands must be defined before similar criteria can be presumed applicable.

More research should be done to:

- Determine the effects of alternating sediment redox conditions on wetland sediment heavy metal retention,
- Verify TIE approaches to toxicant identification for wetland sediments, and
- Develop procedures relating sediment carbon content and the toxicity of nonpolar organic substances.

Wildlife Criteria

Wildlife support is one of the most visible and socially important wetland functional attributes; therefore, protective criteria are critical. Existing wildlife criteria focus on migratory waterfowl toxicity but are being expanded to include additional avian and mammalian species. Criteria being developed for wildlife endemic to wetlands should have direct application to wetland organisms. Wildlife criteria may also represent a means to establish toxicity criteria for those wetlands lacking standing water. These wetlands may require criteria more similar to terrestrial systems — that is, criteria that depend on chemical body burdens.

More research should be done to:

- Develop a toxicity database for wildlife specific to wetlands.

Indicators of Wetland Health

During the development of wetland protective criteria, "indicators" of wetland health should be defined so a wetland's condition can be assessed without extensive process level investigations. Ecological integrity could be determined by measuring the health of surrogates of vegetation, hydrology, sediment, or macroinvertebrates. Research in this area is being supported by EPA's Environmental Monitoring and Assessment Program and the Office of Research and Development's Wetland Research Program.

An approach that integrates wetland protective criteria into a larger landscape management philosophy is being developed by using landscape ecology principles (Gosslink et al. 1990). Studies assessing the importance of wetlands to improving landscape water quality are being conducted at EPA's Environmental Research Laboratory in Corvallis, Oregon. Their approach uses a very general synoptic model, which initially focuses on mapped data. Data derived while developing wetlands protective criteria will be an important model data source. The process will be iterative; the model's ability to estimate the water quality improvement function of wetlands on a broad spatial scale will become more precise as more of the data required for criteria development become available.

Conclusion

Crucial to all aspects of wetland standards and criteria programs is integration of a variety of approaches into protocols that protect wetlands. Biological criteria are critical, and their development is a high research priority. These criteria will be extremely important in determining regulatory success and protecting ecological factors that currently lack protective criteria, such as habitat.

Analysis of existing chemical-specific numeric criteria suggests they are probably as protective of wetland water quality as they are of other surface waters. For those criteria that are not, mechanisms within the existing criteria development framework should be evaluated to adjust the criteria.

Hydrology is a primary driving variable for wetlands, and criteria to protect wetlands from human-induced hydrologic modifications are critical. Narrative criteria must be developed because the experimental frame for numeric hydrologic criteria is lacking. Research into the development of sediment and wildlife criteria must include wetland environmental conditions. Further landscape model development is essential to extrapolate from the protection of a single wetland to the protection of the wetland resource.

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Protecting Wetland Water Quality Standards

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As an environmental advocate for the State of Wisconsin, I have been involved in wetlands issues for years. I speak on behalf of the Wisconsin Office of Public Intervenor, not the attorney general, the Department of Justice, nor, especially, the Department of Natural Resources.

We have been given a good summary of the requirements of the Clean Water Act with regard to developing water quality standards for the wetlands. This is your primer for developing water quality standards. However, it certainly is not the end word because it is lacking a model set of standards, one of the things I would like to see in a document like this. However, the summary is a starting point. I would encourage everyone to get a copy because, if you want to protect wetlands, you'll need information on 401 water quality certification.

In most States, there are no regulatory programs to protect wetlands. We all know that the regulatory handle lies in 404 of the Clean Water Act, which the Army Corps of Engineers administers. We also know that the Corps has a dismal record of protecting wetlands under 404 and that 401 is the way for the States to veto these permits, one of the primary reasons why 401 certification is necessary if States seriously intend to protect wetlands.

I will give you a quick look at portions of rules that the Wisconsin Department of Natural Resources (DNR) is currently proposing. On December 10, 1990, the Wisconsin DNR went to public hearings on Chapter NR103 entitled "Water Quality Certification for Wetlands"—rules that our office, as well as environmental groups in Wisconsin, petitioned for in 1979 and again in 1983.

I reject the notion that developing narrative water quality standards for wetlands is a difficult thing to do from a <u>technical</u> standpoint. To me, the major obstacle for the development of an effective 401 certification program in any State is <u>political</u>. Standards can (and are being) developed, and they can be administered effectively.

Now let's look briefly at Wisconsin's proposed rules. Wisconsin's first mention of wetland water quality standards is in proposed section NR103. It says that the State DNR shall protect water quality-related functional values of wetlands within the range of natural variation—whatever that means. Some of the various values listed are stormwater and floodwater storage, hydrologic functions, filtration, storage of sediment, shoreline protection, and water quality and quantity support. In the proposal, there is a section entitled "Wetlands in Areas of Special Natural Resource Interest." Now, we know that all wetlands are of special interest, but these are the "more special" ones that are adjacent to trout streams, near Lake Michigan, and close to wild and scenic rivers. This list is similar to the outstanding waters noted in many State antidegradation policies.

The critical part of our rule is the decisionmaking standards. It is one thing to consider various values that will be impacted, but, as an environmental advocate, I want to know the basis for an agency's decision, as does the regulated community. The basis for decisionmaking should be a presumption that wetlands should not be adversely impacted or destroyed. The DNR is to protect all present and prospective future uses of wetlands and, to do so, should consider factors including water dependency, practicable alternatives, and impacts that may result.

The decisionmaking standard states that whenever the DNR determines an activity is not water dependent and a practicable alternative exists that will not adversely impact wetlands and/or result in other significant adverse environmental consequences, the DNR shall make a finding that the requirements of this chapter are not satisfied. In other words, certification will be denied. And, for all activities that do not meet the conditions in this paragraph, the DNR shall determine whether the activity will result in "significant adverse impacts." This narrative standard gives pause to environmentalists and industry alike—what does it mean?

Let me give you a short critique. The burden of proof is on the DNR—and I don't think it should be. One of the most useful documents in the EPA guidance is the very last item, Appendix E, which is an example of a State certification decision denying certification and, in numerous paragraphs, there is language such as the following: "All affected wetland areas are important, and to the extent that the loss of these wetlands can be mitigated, the applicant has failed to demonstrate that the mitigation proposed is inadequate. The applicant has failed to demonstrate that there will not be an adverse water quality and related habitat impact. The applicant has failed to demonstrate that there will not be any adverse water quality impacts from increased groundwater levels."

When you go back to your States, make sure the burden of proof lies in the proper place—with the applicant, not on the agency. It is the applicant that should be forced to make the required showing to get a permit and overcome the presumption that filling in wetlands is prohibited.

With regard to the definition of "practicable alternative," consider the concept in the 404(b)(1) guidelines on practicable alternatives. Do not write a rule that allows applicants to paint themselves into a corner and then claim that they have no alternative for their project than to fill the wetland. The 404(b)(1) guidelines do not legitimize that idea, and 401 certification rules should not legitimize allowing buyers to claim hardship that they created for themselves in the event the project fill application is denied. And this also applies to water dependency. Keep the 404(b)(1) concept of practicable alternatives in mind.

The Public Intervenor's office would amend the decisionmaking standards to say the following:

- Whenever the DNR determines that a practicable alternative exists that will neither affect wetlands adversely nor result in other significant adverse impacts, it will deny the permit.

- Whenever the DNR determines an activity is not water-dependent, it will presume that a practicable alternative exists that will avoid adverse impacts on wetlands, unless clearly demonstrated otherwise by a rigorous investigation. (The burden of proof belongs on the applicant.)

- For all activities, the DNR shall determine if the provisions of this chapter are met. Whenever the DNR finds that there is no reasonable assurance of significant adverse impact on wetlands, the permit shall be denied.

Again, keeping the burden of proof on the applicant is essential in decisionmaking. There should be a heavy presumption against nonwater-dependent activities and for which there are practicable alternatives that will not significantly affect water quality.

In Wisconsin, we are adopting these standards to deny 404 permits and, thereby, protect wetlands. Also, we are proposing a department self-audit. Before the program goes into effect, we must determine how many wetland acres are being lost; afterward, we should audit to determine how effective the rules are. We should send these reports to the legislature or the governor and publicize the effectiveness of the program.

Questions, Answers, and Comments

Q. *(John Bender—Nebraska Department of Environmental Control) This panel has called for hydrologic criteria, and in Nebraska, hydrologic modification (filling or draining of wetlands) is the big problem. Everything else—nonpoint sources, chemical contamination, point sources—make up less than 5 percent of the problem for our wetlands. Please address these two questions: The preamble of the Clean Water Act says something about "States rights for appropriation of flows and quantities" and pretty much segregates quantity issues from the quality issues. How do you get around that with hydrologic criteria? Assuming that we can get around that, what do you do with these hydrologic criteria when curve engineers do not take jurisdiction and it's a drainage project, not a fill?*

A. The quantity and quality issue is really critical. If you don't have the water regime necessary to maintain that wetland, you will suffer some damages, either accumulations of sediment or accumulation of sediment followed by downcutting. A lot of our areas have been damaged in that way through diversions either of new water into the system or water out of the system. States will have to resolve that issue because of the way their water allocation laws are set up.

C. If the court does not have jurisdiction, States don't have jurisdiction; if they can't find a Federal handle, then 401 certification doesn't apply. If the handle exists (somebody is digging a ditch and discharging spoil right into the wetlands), then I really don't see a serious problem dealing with quantity and quality issues. As groundwater and surface water ecologists and hydrogeologists have told me, you really can't separate quality and quantity issues and should be able to find ways to draw the linkage between the two.

Q. *I think that's our real concern. Is there any solution to where 404 doesn't apply?*

A. (Mary Jo Garreis—State of Maryland Department of the Environment) There is because I have experienced it. Maryland probably has the most aggressive 401 certification program in the country, but early on we ran into a problem: if you excavate and don't fill, then you're not covered by 401, at least by current interpretations. However, under the 401 interpretation, you are covered by anything that has potential to carve a discharge or to violate a water quality standard. We take water quality standards interpretation probably to the maximum; our basic use standards say that our water quality standards protect fish and other aquatic life (we declare wetlands other aquatic life) and just take off from there. We have used that quite successfully; if you are digging a wetland, you are disturbing other aquatic life.

In 1989, Maryland passed a nontitled wetlands protective act that requires a permit for any work in wetlands. It goes further than 401 certification in that it covers any activity in wetlands. We have required titled permits (required permits in titled wetlands) since 1983, so we have two laws in the book. In 1983, we began using the Water Quality Certification Program to geographically protect particularly nontitled wetlands until we could get the Wetlands Protective Act on the book. A State like Maryland that has a whole set of laws to protect titled and another set for nontitled wetlands has a good grasp of the 401 water quality program that has been using our water quality standards.

As for general narrative language, we see no advantage in using the recommended EPA approach; in fact, if I tried to use that approach in my State, I would be crucified on the grounds that it is another bureaucratic move in what is already an extremely complicated process. We have had meetings to eliminate duplications of authority and activity with the Army Corps, EPA, Fish and Wildlife Service, and our three State agencies. How does the EPA guidance intend to account for States that have elected to protect wetlands in other ways than using specific water quality standards (in other words have specific acts directed to wetland protection)? A lot of States are going about it in different ways and could actually put the process backward, instead of forward, by causing confusion.

C. That's the kind of exemption from the program I'd like to have to worry about.

C. (Mary Jo Garreis) Well I'm worried because it could be a real political nightmare for me.

C. I work with the water quality standards program at EPA headquarters. Our view of water quality standards for wetlands is based on our responsibility under the Clean Water Act, which requires that water quality standards be set for all waters of the United States and based on the regulatory definition of waters of the United States, which can include wetlands. At the State level, programs might be duplicated when other means were adopted earlier. However, this does not allow our program to say that we are not required to carry out that responsibility under the Clean Water Act. I'll bring this issue to my management—to find out how EPA can work with States that have used other regulatory programs to protect the water quality of their wetlands.

C. (Mary Jo Garreis) In a time of limited resources and duplication of efforts where everybody is touchy about over-regulations, you'd better come up with a solution. Nobody is going to buy that argument.

C. (Jaime Kooser—Wetlands Section of the Washington State Department of Ecology) I have spent the last 11 months writing wetlands water quality standards for the State of Washington. I would be happy to send you a copy of our draft rule.

We are participating in the triennial review of Washington State. Wetlands are only one of the many important issues that are being handled. Filing of the Wetland Water Quality Standards would be part of that process. But our schedule is dictated by the triennial review rather than by just being able to have a leisurely amount of time to develop standards. Obviously, Washington is getting a head start. Most States will be dealing with this on the next triennium. Hopefully, what Washington has done, as well as Wisconsin and other States, will give you all a good head start.

There are a couple of things that you should pay attention to in writing such standards. First, develop a mitigation policy. One question that surfaced quickly was, what is the relationship between mitigation and the antidegradation implementation plan? Clearly, activities that degrade wetlands will continue, and they will have to be mitigated. Figure out how a mitigation policy for wetlands would fit in with your antidegradation plan. In particular, this means that States must pay more attention to their outstanding resource waters program. In Washington State, no such waters are presently designated, but we are working on this in the antidegradation plan. It is an important way to protect wetlands that are designated "pristine."

People must also pay attention to stormwater. In Washington State, we have a research project called the Puget Sound Wetlands and Stormwater Management Research Program, which is determining how wetlands can be used appropriately in dealing with stormwater. Wetlands receive much nonpoint source pollution either by design or by accident—what should be done? Nonpoint sources, which are difficult to deal with, will not be covered under 401 certification processes.

The major battle is a political one; that's going to be true for all those things that are not 401 certification problems in your State. I can share some of the results from that stormwater research group. Hopefully, we can make the task of writing such standards an easier one for other States.

C. You have to be very serious about mitigation so that it doesn't degenerate into a mechanism by which developers say let's make a deal. That's happened at the Army Corps of Engineers level, and it can happen at the State level. You must link mitigation directly to decisionmaking standards; you've got to have a strong standard so that people don't try to trade a duckpond for a wetlands. Developers are doing this now. I would hate to see States get into that same problem.

C. (Jaime Kooser) Our mitigation policy clearly states no net loss for both function and acreage. That may cost us a lot in some areas, but it's clearly stated because we don't want the developers to be in that position. And although I agree with you that the application needs to show the burden of proof, it's very clear in our mitigation policy that appropriateness is determined by the department. In other words, it will be up to the Department of Ecology to decide if the mitigation being proposed is appropriate or acceptable. The standard method of going through that has to be crystal clear in the policy.

C. Within our program, stormwater research has one of the highest priorities. It's likely that we will begin some type of stormwater research program, really extending the work done by EPA.

Q. *I have a question for Larry Schmidt. You had good ideas on what might be done by the Forest Service. What is its commitment (in terms of resources) to ensure that there are appropriate BMPs, that they are applied properly, and that there is follow-up to assure consistent improvement? Have you considered any program to actively involve citizen groups in the follow-up work?*

A. (Larry Schmidt) We do have a limited staff. We try to get the BMPs designed and implemented as part of the ongoing programs and go out and check them by a sampling type of process. However, we don't have a complete idea of what's being delivered out there, and that is a concern.

Q. *Has the Forest Service as an agency made a resource commitment to follow up?*

A. I think we have, within our capacity.

Q. *In other words, fairly little?*

A. Yes.

Q. *Would the Forest Service actively recruit public citizen groups?*

A. We haven't actively recruited the public, although we have involved citizens in some of the monitoring review.

Q. *Would you be willing to go back to the Forest Service and propose this as a method for increasing your manpower?*

A. It's one course we've considered, and we are using volunteers. We need more of that kind of effort for BMPs, but monitoring would help.

C. (Marge Coomb—Florida Department of Environmental Regulation) Florida's Standards and Monitoring Section is looking at specific water quality standards for wetlands. There are other ways besides 401 certification to protect wetlands; as a matter of fact, I was with the Wetlands Permitting Section for a year before I knew there was anything called 401 certification.

Florida has a separate permitting program for those who need a permit for dredging or filling in, on or over waters of the State to a landward extent—and we have definitions of what constitutes landward extent and waters of the State based on soil, hydrology, and vegetation.

For any dredge and fill activity—and now for any discharges as part of our antidegradation program—we have permitting criteria that are based on impacts on fish and wildlife and their habitats, including threatened and endangered species, hydrologic impacts, and marine productivity. These criteria are not water quality standards per se but rules in the statutes. For reasonable assurance, the burden of proof is based on the applicant, and all projects have to go through a public interest criteria test.

C. Those people who do not want water quality standards for wetlands to move forward will use the argument that you should have quantitative water quality standards. There is no such thing as a "quantitative standard" or fill in a wetland, it's either you do or you don't. With respect to stormwater, however, I think EPA is headed in the right direction. However, the things EPA is doing at the research level are not appropriate for developing quantitative standards as they might apply to dredge and fill programs because they just don't work.

C. I don't want to give the impression that you don't need water quality standards, but I do find it ironic that, in some States, if you stick a pipe into wetland, the Agency would say you need a permit to discharge wastewater. You can argue how applicable the standards are but at least the regulators would jump forward; however, if somebody backs another point source—a dump truck—up to the wetland and obliterates it, those same regulators don't have a way to handle that. The dump truck is violating the suspended solid standards.

If you really want numerical standards, you don't need linkage between water quality and numeric and narrative standards. Numeric standards should not be an excuse for not going forward with narrative standards, doing what you can while developing strategies that take into account the water quality regime from wetlands as opposed to surface waters. Agricultural industries are going to complain about the rules; well, I'm perfectly willing to talk to them about numeric standards, about the quality water that should come out of their ditches, but they have an exemption in water standards that they don't like to talk about.

Q. *Since the first action for States to take is to include wetlands in the definition of State waters, and two speakers have talked about having developing State definitions of wetlands, I'm wondering how you can reconcile those definitions with the Federal ones? Are your boundaries more or less inclusive and is it or is it not acceptable to EPA?*

A. Somebody told me once that there were 50 definitions for wetlands. In the criteria, it says that the "State may choose to include riparian and flood complaint ecosystems as a whole in the definitions of water of the State," and it may seem that we are going beyond the classical definition of wetlands.

The Corps, EPA, and Fish and Wildlife Service have argued about the Federal definition for years. The value of the manual was in a set of rules we had to follow so people couldn't put in their own interpretations.

Q. *(John Bonine—Environmental Law Clinic, University of Oregon) Tom, doesn't Wisconsin require that dump trucks get NPDES permits? It was held in AUL Sportsmen* vs. *Alexander that dump trucks are point sources of water pollution under NPDES; maybe some NPDES suits should be brought against those dump trucks.*

A. (Thomas Dawson) I have argued for years that that situation exists but I've gotten resistance from the legal staff at the Department of Natural Resources who argue that you separate 301 from 404 and that separation could co-exist in State law. I disagree with that. It's one thing to talk about bringing a lawsuit and it's another to take it to the current Wisconsin court where we probably will lose. I'll wait until a transition and then maybe think about bringing up that case.

Q. *(Bill Wilen) What does the audience think is the single most important need from EPA? They had* *the manual; you want to draft water quality standards. Is there one overriding need that EPA could provide to help States head down the road to water quality standards?*

A. Spend money.

C. I don't think it's what EPA has to do necessarily with respect to water quality standards. Again, going back to the 404 permit program, EPA has to start working with the U.S. Army Corps of Engineers because it has not fulfilled the mandate they have under the Clean Water Act. EPA is sort of a partner with the Corps in the implementation of the act. We need EPA's support to bolster or backup the Corps' program to make sure that it is operating to fulfill the mission of the Clean Water Act as opposed to caving in to any permittee that walks in the door.

C. This time, I agree with you 100 percent, Duane.

Q. *What's the most important step for a State when it wants to enact water quality standards for wetlands?*

A. The most important thing is being able to consider habitat values prior to the 1984 Wetlands Protection Act. The only thing we could do was link private decisions with water quality standards. We had a lot of bluffing before that but being able to specifically look at habitat is the biggest step.

Q. *How did you overcome that?*

A. By including it in the statutes as far as determining criteria as part of the public interest.

Q. *For the State?*

A. Yes. In Washington State, the driving factor was a desire to improve the use of the 401 certification process. Wetlands have always been considered waters of the State in Washington, although they are not specifically included in our definitions of water of the State. An attorney general option is included in Canadian legislation.

However, there's been confusion because of what was not specifically listed, so we do need to include wetlands. Because they have always been considered waters of the State, they have been protected. The problem is that, because the 401 process isn't as clear as it should be, the State has been using the water quality standards as it is currently written, which is a lot harder. We are fortunate because we haven't been challenged in court on our 401 certifications.

The problem in Washington State is that, for the last three years, our wetlands bill has died in the legislature. We now have an executive order from Governor Gardner that directs us to do a lot of wetlands protection, but it also says specifically to "get wetland standards." As States together, we need to talk about how to put together the most effective package deal. Smaller states like Connecticut already have completed inventories and some legislation. In Washington State, there isn't a complete inventory; we don't know where all the wetlands are. You have to think about how to organize your package deal. Wetlands water quality standards are one element in a larger package—you can't expect them to solve every problem. But the first and biggest problem is getting the 401 process into water quality because that would go a long way in getting the other pieces of the puzzle to fit.

C. I'd like to go back to the comment that the most critical issue is dredge and fill, the presence of water. For that reason, I would urge that you not give up on your State legislation because I would hate to see you try to corrupt old-time water quality standards with new concepts. Let's get the State laws that say "Thou shalt not dredge and fill wetlands" and continue to work on that being the big tool.

C. But that's easier said than done and the fact is Wisconsin, which is considered an environmentally progressive State, has for years attempted to get wetlands legislation, and it has been consistently defeated; 401 is one of the few handles we already have and can implement. Since the department already has the authority to adopt them, let's go out there and work for wetland bills, but there are things we can do that are realistic that can go into place now, and that's 401 certification.

One thing you need to recognize, though, is that 401 does not cross-reference the line with section 404 in the Clean Water Act and, therefore, there is a serious jurisdictional problem when we talk about using 401 to regulate what is more than an acre of land and what should be local determination of 401 with the water quality standards effluent limitations. Legislative control is another topic entirely and is actively addressed by local legislation.

C. I disagree. Even when we are talking about wetlands, we are talking about waters of the United States and you are only playing on the developers' turf when you allow them to emphasize the word "land." What the Clean Water Act is all about is protecting the physical, biological, and chemical integrity of water. We are not talking about land use—we are talking about the integrity of water and what water gives us in the quality of our life. I disagree strongly with the view that this is some sort of subversive land use conspiracy, that we protect water and cannot separate water in wetlands from hydrologic systems.

BIOLOGICAL CRITERIA

Answering Some Concerns About Biological Criteria Based on Experiences in Ohio

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Introduction

Biological criteria have been receiving increased national attention among the States and from the U.S. Environmental Protection Agency (EPA). The Agency has published national program guidance for biological criteria (U.S. Environ. Prot. Agency, 1990) and will require States to develop narrative biological criteria by 1993, evidence that this is a priority in its water quality program.

In Ohio, biological assessments and corresponding evaluation criteria have been used extensively since 1980. Use and evaluation of ambient biological data underwent an evolutionary process, from narrative descriptions of community attributes in the early 1980s to the numerical biological criteria adopted into Ohio's water quality standards regulations in February 1990.

The way regulatory agencies have assessed and managed surface water resources has undergone significant changes in the past 10 years. What was primarily a system of simple chemical criteria that served as surrogates for the biological integrity goal of the Clean Water Act has matured into a multidisciplinary process that includes complex chemical criteria and standards for whole effluent toxicity and biological community performance. This integrated approach has allowed surface water management programs to focus beyond water quality and consider the surface water resource as a whole.

Simply stated, controlling chemical water quality alone does not assure the integrity of water resources (Karr et al. 1986; Ohio Environ. Prot. Agency, 1990a); this results from the combination of chemical, physical, and biological processes (Fig. 1). To be truly successful in meeting this goal, we need monitoring and assessment tools that measure both the interacting processes and integrated result of these processes. Biological criteria offer a way to measure the end result of water quality management efforts and successfully protect surface water resources.

In addition to accurately assessing water resource health, the challenge of accounting for the landscape's natural variability was addressed through the use of ecoregions (Omernik, 1987) and regional reference sites (Hughes et al. 1986, 1990). Ecoregions delineate variability in major landscape features at a level of resolution that is easy to apply in statewide water quality standards (Gallant et al. 1989). Ecoregions in Ohio are transitional; they range from the flat, extensively farmed northwest section to the highly dissected, unglaciated east and southeast part of the State (Omernik and Gallant, 1988). In Ohio, numerical biological criteria are organized by ecoregion, organism group, site type, and use designation (Yoder, 1989; Ohio Environ. Prot. Agency, 1990b).

Biological Criteria: Questions and Concerns

Although biological assessments have been a part of some State monitoring efforts for many years, only recently has the need for and acceptance of ambient biological criteria been recognized. In many traditional water quality circles, the validity and efficacy of biological criteria are often questioned or misunderstood. This presents a paradox because biological criteria directly express what water quality criteria are designed to achieve.

In an effort to address some of these concerns, we have posed the following five questions about biological criteria and answered them with real world examples from our experiences in Ohio.

1. Are ambient biological measures too variable to use in assessing surface water resources?

A frequent criticism of ambient biological data is that it is subject to natural and anthropogenic variations and therefore too "noisy" to function as a reliable component of surface water resource management. Natural biological systems are variable and seemingly "noisy," but no more than the chemical and physical components that exist within them. Certain components of ambient biological data are quite variable, particularly those measures at the population or sub-population level.

Single dimension community measures can also be quite variable. However, the advent of new generation community evaluation mechanisms such as the Index of Biotic Integrity (IBI) (Karr, 1981; Karr et al. 1986) have provided sufficient redundancy as to compress and dampen some of this variability. Rankin and Yoder (1990) examined replicate variability of the IBI from nearly 1,000 sites in Ohio and found it to be quite low at least-impacted sites (Fig. 2). Coefficient of variation (CV) values were less than 10 percent at IBI ranges indicative of exceptional biological performance, which is lower than that reported for chemical laboratory analyses and interlaboratory bioassay variability (Mount, 1987). Variability as portrayed by CV values increased at the IBI ranges indicative of impaired

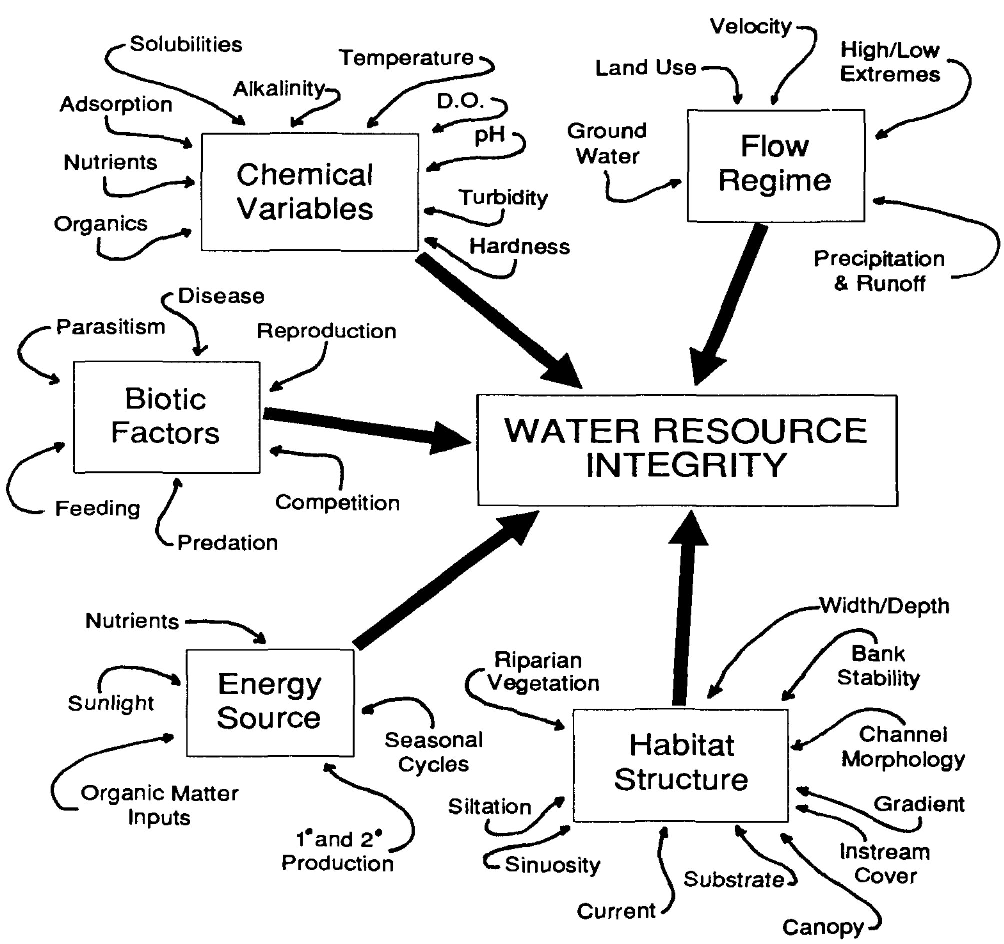

Figure 1.—The five principal factors, with some of their important chemical, physical, and biological components, that influence and determine the resultant integrity of surface water resources (modified from Karr et al. 1986).

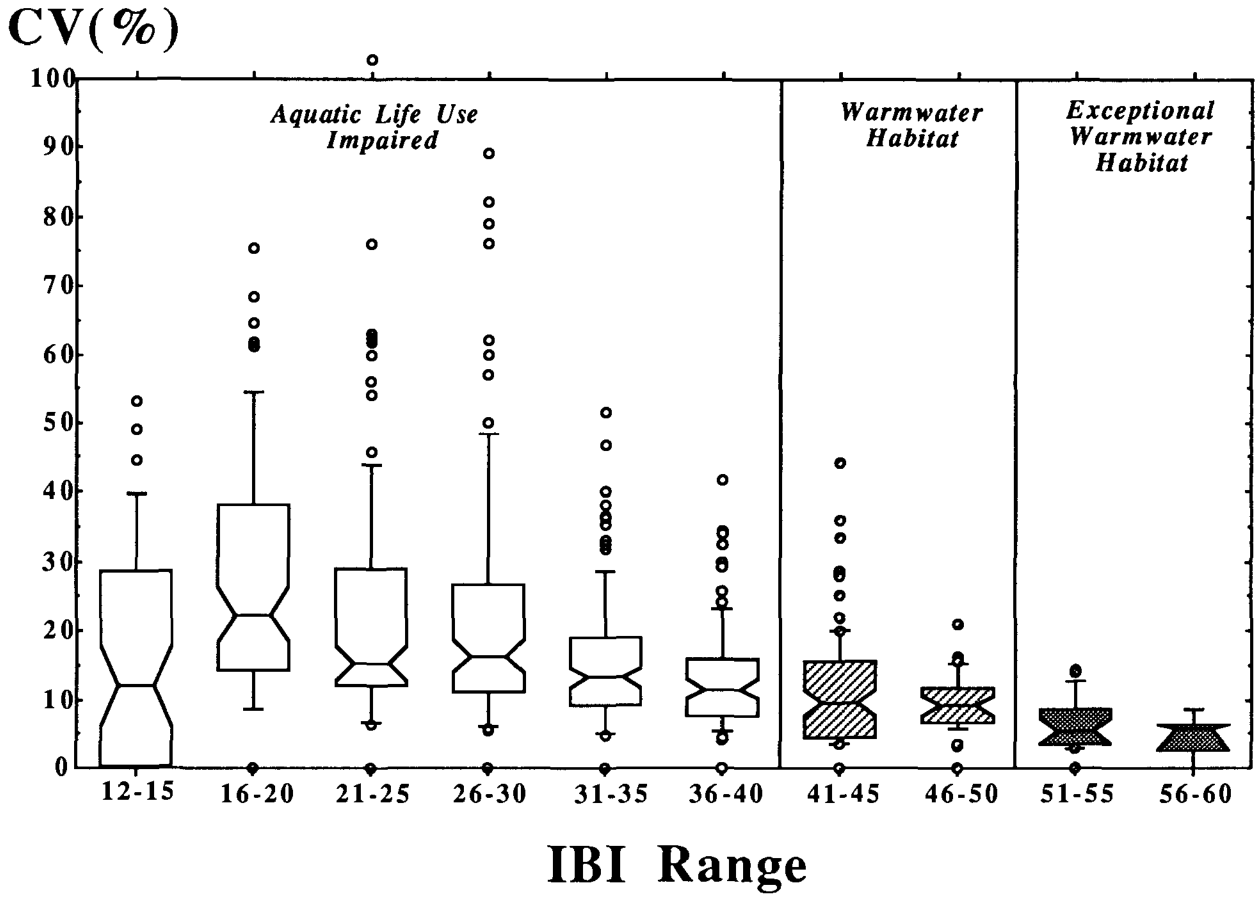

Figure 2.—Coefficient of variation (CV) for a range of IBI scores at sites with three sampling passes per year. Boxes show median, 25th and 75th percentiles and minimum, maximum, and outlier values.

biological performance. Low variability was found for Ohio's Invertebrate Community Index (ICI) with a CV of 10.8 percent for 19 replicate samples at a relatively unimpacted test site. Other researchers have reported similarly low variability with ambient biological evaluations (Davis and Lubin, 1989; Stevens and Szczytko, 1990).

Cairns (1986) suggested that differences in variability rather than differences in averages or means might be the best measure of stress in natural systems. Not only is the variability of the measures used to implement biological criteria low, the degree of variability encountered can be a useful assessment and interpretation tool.

Ohio EPA has addressed the variability inherent to biological measures in three general ways:

1. Variability is compressed through the use of multimetric evaluation mechanisms such as the IBI and ICI.
2. Variability is stratified through use of a tiered stream classification system, ecoregions, biological index calibration, and site type.
3. Variability is controlled through standard sampling procedures that address seasonality, effort, replication, gear selectivity, and spatial concerns.

Lenat (1990) also described similar approaches to controlling and thus reducing variability in ambient biological samples.

2. Are biological criteria sufficiently sensitive to serve as a measure of surface water resource integrity?

Conceptually, direct biological measures should be sufficient to measure water pollution control goals and end points that are fundamentally biological. However, this fact alone is an insufficient test of the efficacy of biological criteria and attendant assessment methodologies. Evaluation against currently accepted assessment methods is one way to test the comparative sensitivity of biological criteria. This was accomplished in the 1990 Ohio 305b report (Ohio Environ. Prot. Agency, 1990a), where comparisons were made of the relative abilities of biological and chemical water quality criteria and whole effluent toxicity tests to detect aquatic life use impairment.

In comparing biological with chemical water quality criteria, a database was used that consisted of 625 waterbody segments. Individual waterbody segments averaged 10.6 miles in length (range: 0.5-41.2 mi.) and had one or more chemical and biological sampling locations. Biological data consisted of fish and/or macroinvertebrate results. Water chemistry data consisted of grab samples at an average of 3.6 samples per site (range: 1 to 13 samples) and included parameters commonly measured by most ambient monitoring networks. (Ambient grab samples usually consist of dissolved oxygen, temperature, conductivity, pH, suspended solids, ammonia-N, nitrate-N, nitrite-N, total Kjehdahl nitrogen, phosphorus, and toxics such as cyanide, phenolics, copper, cadmium, chromium, lead, nickel, iron, and zinc on an as-needed basis.)

Ohio's recently adopted biological criteria were used to define biological impairment and the Ohio Water Quality Standards (WQS) were used to determine exceedances of chemical results. The comparison showed that biological impairment was evident in 49.8 percent of the segments where no ambient chemical water quality criteria exceedances were observed (Fig. 3). Both the biological and chemical assessments agreed about impairment (or lack thereof) in 47.4 percent of the waterbody segments. Chemical impairment was evident in the remaining 2.8 percent of the segments where no biological impairment was found. While much of the concern expressed about biological criteria has been with its potential use to "dismiss" chemical exceedances, such as the latter case, the most important finding of this analysis was with the ability of the biota to detect impairment in the absence of chemical criteria exceedances. An initial reaction to these results might be to view chemical criteria as not being sufficiently protective. However, further analysis of the reasons behind these results shows that the stringency of the chemical criteria is not an important issue. In the 49.8 percent of the segments with biological impairment alone, the predominant causes of impairment were organic enrichment/dissolved oxygen, habitat modification, and siltation (60.4 percent of the impaired segments). None of these, except very low dissolved oxygen, are measurable by direct exceedances of chemical water quality criteria.

Chemical causes of impairment were predominant in a minority of the cases (30.7 percent). In the absence of chemical criteria exceedances from the water column, this cause was deemed important because of information such as sediment contamination or effluent data that indicated periodic chemical problems not readily detectable by grab sampling. In this case, it was the failure of the chemical sampling effort to detect exceedances in the water column, primarily because of an insufficient sampling frequency, parameter coverage, or both. In many segments, both chemical and nonchemical causes occurred simultaneously, resulting in cumulative effects evident only in the biological results.

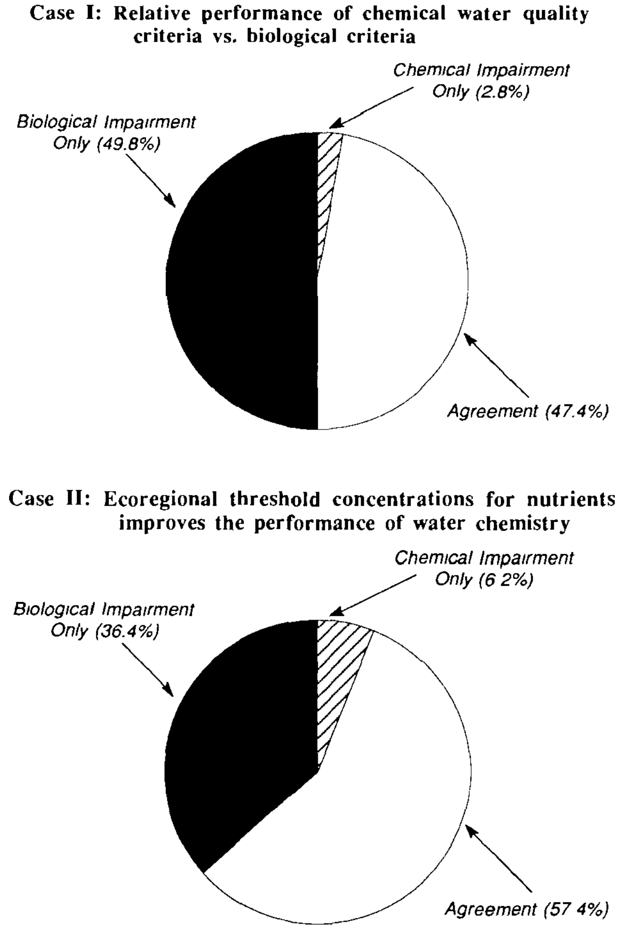

Figure 3.—Comparison of the abilities of biocriteria and chemical criteria to detect impairment of aquatic life uses in 625 waterbody segments throughout Ohio. Data were based on chemical water quality criteria currently in Ohio's water quality standards (upper) and supplemented with nutrient data using threshold values from ecoregional analysis (lower).

Another important factor to consider is that chemical criteria in this evaluation are used in an ambient application. Thus, factors such as sampling frequency, temporal variability, parameter coverage, and dilution dynamics can be of equal, if not overriding, importance as the stringency of the chemical criteria. One of the most important applications of chemical criteria is as design standards where factors such as design flows and safety factors tend to make up for their apparent inadequacies. This is not to say that chemical criteria can never be too stringent or lenient. Such situations are likely to arise on a site-specific basis, where unique regional or local conditions result in differences.

The performance of the chemical assessment relative to the biological was improved by including ecoregional threshold exceedances for nutrient parameters (nitrogen series, phosphorus), for which no aquatic life criteria exist (Fig. 3). By using the Ohio regional reference site database, threshold values for these parameters were established as 75th percentile concentrations. This reduced the frequency of segments with biological impairment alone to 36.4 percent. Again, the reasons are complex and were most often related to the coincidental occurrence of higher nutrient concentrations with predominant impacts such as organic enrichment, siltation, and habitat modification. Further work with ecoregional threshold values for additional chemical parameters may enhance the use of ambient water chemistry results for broad scale assessments such as the biennial 305b report and nonpoint source assessment.

An initial comparison was also made with bioassay results from 43 entities where receiving stream biosurvey data was available. The bioassay results represent 96-hour acute-definitive tests of the effluent and immediate mixing zone area. In-stream biological impairment was observed in nearly 60 percent of the comparisons where acute toxicity >20 percent was observed only in the effluent (Fig. 4).

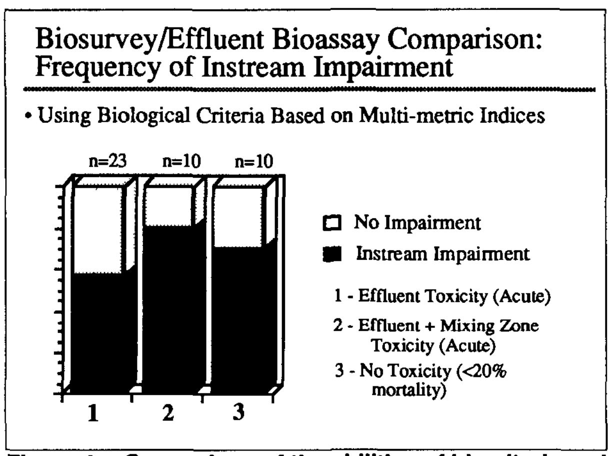

Figure 4.—Comparison of the abilities of biocriteria and acute bioassays to detect impairment of aquatic life uses at 43 locations throughout Ohio. Frequency of in-stream impairment is compared against: (1) effluent toxicity >20 percent only; (2) effluent and mixing zone toxicity >20 percent; and (3) no toxicity (≤20 percent).

For the cases where >20 percent mortality was observed in both the effluent and mixing zone, 8 of 10 comparisons showed in-stream biological impairment. In the remaining cases where no significant mortality (≤20 percent) of bioassay organisms was observed, biological impairment was observed in 7 of 10 comparisons. Again, the reasons for these discrepancies are complex but similar to the previously discussed comparison where biological impairment was observed in the absence of chemical criteria exceedances. Although more detailed analysis of these comparisons is needed, there was a general relationship between the severity of the bioassay toxicity and the existence of in-stream biological impairment (Ohio Environ. Prot. Agency, 1990a).

3. By using a regional reference site approach for establishing biological criteria, are aquatic life goals being set too low?

The debate about how attainable condition should be defined began in the 1970s with discussions on how to define and measure the Clean Water Act goal of biological integrity. Initial attempts failed to bring about a quantitative approach (Ballantine and Guarraia, 1975), but an acceptable definition was eventually forthcoming. This has been referred to as the operational definition of Karr and Dudley (1981), which essentially translates into the "biological performance and characteristics exhibited by the natural habitats of a region."

This provides the theoretical basis for designing a regional monitoring network of least impacted reference sites (Hughes et al. 1986) from which quantitative, numerical biological criteria can be derived. The specific approach used by Ohio is discussed elsewhere (Ohio Environ. Prot. Agency, 1987, 1989a; Yoder, 1989). The methods used to select and monitor reference sites, calibrate the biological evaluation mechanisms (IBI, ICI), and set the ecoregional biological criteria are inherently conservative and guard against biases that may result in underprotective biological criteria.

Reference-site selection guidelines are necessarily qualitative and are described in detail in Whittier et al. (1987) and Ohio EPA (1987, 1990b). In Ohio, which has had extensive landscape disturbance, the goal is to select least impacted watersheds to serve as a reflection of the current-day biological potential. Reference sites are selected according to stream size, habitat characteristics, and the absence of direct point source or obvious nonpoint source pollution impacts.

The "least impactedness" of reference sites in the extensively disturbed Huron/Erie Lake Plain (HELP) ecoregion of northwest Ohio is much different from that in the less-disturbed Western Allegheny Plateau (WAP) of southeastern Ohio and the other three ecoregions. Such background conditions can be unique to each region and, as such, define the present-day potential.

A criticism of this approach is that it relegates these areas to being no better that they are presently. However, an important element of regional reference sites is the re-monitoring effort designed to take place once every 10 years after which any changes in the background potential can be reflected in the calibration of the biological evaluation mechanisms, the biological criteria, or both. This maintenance effort will ensure that the biological criteria do not underrate the attainable biological performance within each region of the State.

The method of calibrating the biological evaluation mechanisms, such as the IBI and ICI also protects against underprotective criteria that might result from including possible suboptimal reference sites. The calibration methods for the IBI as specified by Fausch et al. (1984) include plotting reference site results for each IBI metric against drainage area (a reflection of stream size). The first step is to draw a maximum species richness line, beneath which 95 percent of the data points occur. This represents the line beneath which the area of the graph is trisected resulting in the 5, 3, and 1 scoring criteria common to each of the 12 IBI metrics (Fig. 5).

The Ohio EPA ICI for macroinvertebrates is calibrated in a similar manner, except that the area beneath the 95 percent line is quadrisected in conformance with the 6, 4, 2, 0 scoring configuration of the 10 ICI metrics (Fig. 5). Where the 95 percent line is drawn is controlled by the upper surface of points that represent the best results obtained statewide for that metric. Thus, the influence of any sub-optimal or marginal data (whether these are due to unknown impacts or poor sampling) in the calibration of the IBI or ICI is virtually nil. This technique induces an inherent element of conservatism into the eventual biological criteria.

When the biological index values for the IBI and ICI are calculated for each reference site sample, the biological criteria for each index can then be derived. This process is not entirely mechanical and involves making some value judgments about how biological criteria will be selected. Ohio's water quality standards specify a tiered system of aquatic life use designations, each with a narrative definition that specifies the biological attributes that waters attaining that use should exhibit. For the warmwater habitat (WWH) use designation, which is the most commonly applied aquatic life use in Ohio, the 25th percentile value of the reference site results was selected as the applicable biological criterion. Ohio EPA decided that most of the reference results should be encompassed by this base level use for Ohio's inland rivers and streams. Also, by excluding a fraction of the reference results, any unintentional bias induced by suboptimal or marginal results caused by factors that were not apparent in the initial selection process would be minimized or eliminated.

When the insignificant departure tolerances for each index are considered, less than 5 to 10 percent of the reference results fail to attain the biological criteria for the WWH use. For instance, insignificant departure from IBI and ICI values are 4 units each (Ohio Environ. Prot. Agency, 1987). If the ecoregion IBI criterion is 42, a value of 38 would be considered to attain the biological criterion but would be regarded as

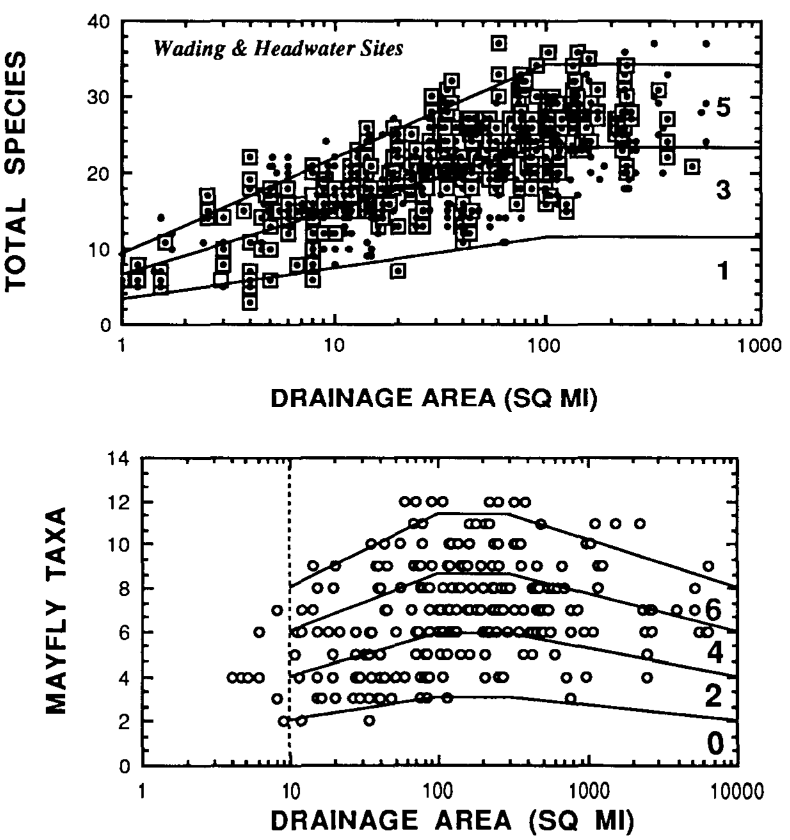

Figure 5.—Example of the technique used to calibrate the Index of Biotic Integrity (IBI) and the Invertebrate Community Index (ICI) for the metrics of each index. The number of fish species vs. drainage area for headwaters and wading site types (top panel) and number of mayfly taxa vs. drainage area (bottom panel) demonstrate the use of the 95 percent maximum line and the trisection and quadrisection methods used to establish the IBI and ICI metric scoring criteria.

an insignificant departure for risk management purposes.

This process is similar to the use of safety factors for toxicological applications and has previous precedents such as using the 75th percentile pH, temperature, and hardness to derive design unionized ammonia-nitrogen and heavy metals criteria, 20 percent mortality for bioassay results, or even using the 10^{-6} risk factor for carcinogens. In this sense, the 25th percentile acts as a safety factor in the derivation process. Because of unique problems with selecting reference sites in the highly modified HELP ecoregion, a different benchmark (upper 10 percent of all sites) was used to set the WWH biocriteria. The approach of setting attainable biological criteria is stratified by ecoregion (WWH use), site type for fish, and a tiered system of aquatic life use designations (Fig. 6). Rules for determining use attainment also provide safeguards: full attainment of a use requires achievement of the biological criteria for both fish and macroinvertebrates.

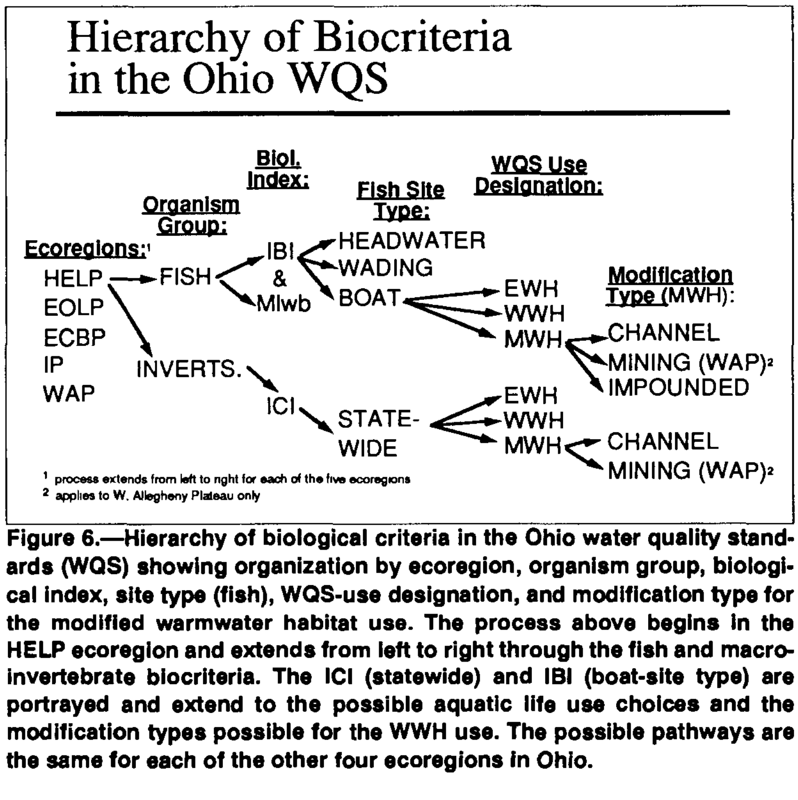

Figure 6.—Hierarchy of biological criteria in the Ohio water quality standards (WQS) showing organization by ecoregion, organism group, biological index, site type (fish), WQS-use designation, and modification type for the modified warmwater habitat use. The process above begins in the HELP ecoregion and extends from left to right through the fish and macroinvertebrate biocriteria. The ICI (statewide) and IBI (boat-site type) are portrayed and extend to the possible aquatic life use choices and the modification types possible for the WWH use. The possible pathways are the same for each of the other four ecoregions in Ohio.

4. Are the data collection costs associated with biosurveys and biological criteria unduly expensive?

Ambient biological assessments have had the unfortunate reputation of being time-consuming, intensive, and expensive. Oftentimes, this reputation has been a deterrent to using biosurveys in assessing surface water resources and in promoting surrogate methods of assessment (U.S. Environ. Prot. Agency, 1985).

The issue of cost has been addressed extensively in Ohio, where we have compared the relative resource requirements of ambient chemical assessment, bioassays, and biosurveys employing both fish and macroinvertebrates (Ohio Environ. Prot. Agency, 1990c). This comparison found that, for entity evaluation and stream surveys, biosurveys employing both fish and macroinvertebrates were cost-competitive with ambient chemistry and effluent bioassays (Table 1). While biosurveys may be comparable in terms of cost, it does not seem prudent to view these data in a competitive sense. Rather, the integrated use of all tools is necessary to ensure accuracy of evaluation and hence regulation. The well-worn metaphor of the three-legged stool is still appropriate.

A renewed focus on ambient biological assessment methods has resulted in the development of cost-effective strategies that also yield reliable and accurate information. Accuracy and reliability must accompany the cost effectiveness of the chosen approach. The importance of this concept is partially illustrated by an analysis of the different accuracies inherent to narrative and numerical biological as-

Table 1.—Comparison of the cost of ambient chemical, bioassay, and biosurvey assessment on an entity and stream survey evaluation basis, using cost data from Ohio EPA in FFY 1987 and 1988. This is based on an example that includes three point sources discharging to a medium-sized river in an urban and rural setting in Ohio.

CATEGORY	CHEMICAL	BIOSURVEY	BIOASSAY
Samples	90	12	9
Unit cost/sample	$360	$1,850	$ 1,850 (acute)[1] $ 3,050 (7-day)[2]
Survey cost	**$32,400**	**$22,200**	**$16,650** (acute)[1] **$27,450** (7-day)[2]

Source: *The Cost of Biological Monitoring* (Ohio Environ Prot Agency, 1990c)
[1] 96-hour definitive test using *Ceriodaphnia* and fathead minnow
[2] 7-day acute/chronic test using a 24-hour composite sample

sessments. The evaluations yielded by Ohio's narrative macroinvertebrate criteria used from 1979 to 1986 and the ICI calibrated by using regional reference sites were compared across more than 400 sites sampled between 1981 and 1987.

The results indicated that the narrative approach overrated sites as being better than indicated by the calibrated ICI (Fig. 7). The narrative approach rated as "good" (attaining the WWH use) 36 percent of sites classified by the ICI as impaired, and as "fair," 21 percent of sites classified "poor" by the ICI. Only 1.3 percent of sites rated "poor" by the narrative method were classified "fair" by the ICI.

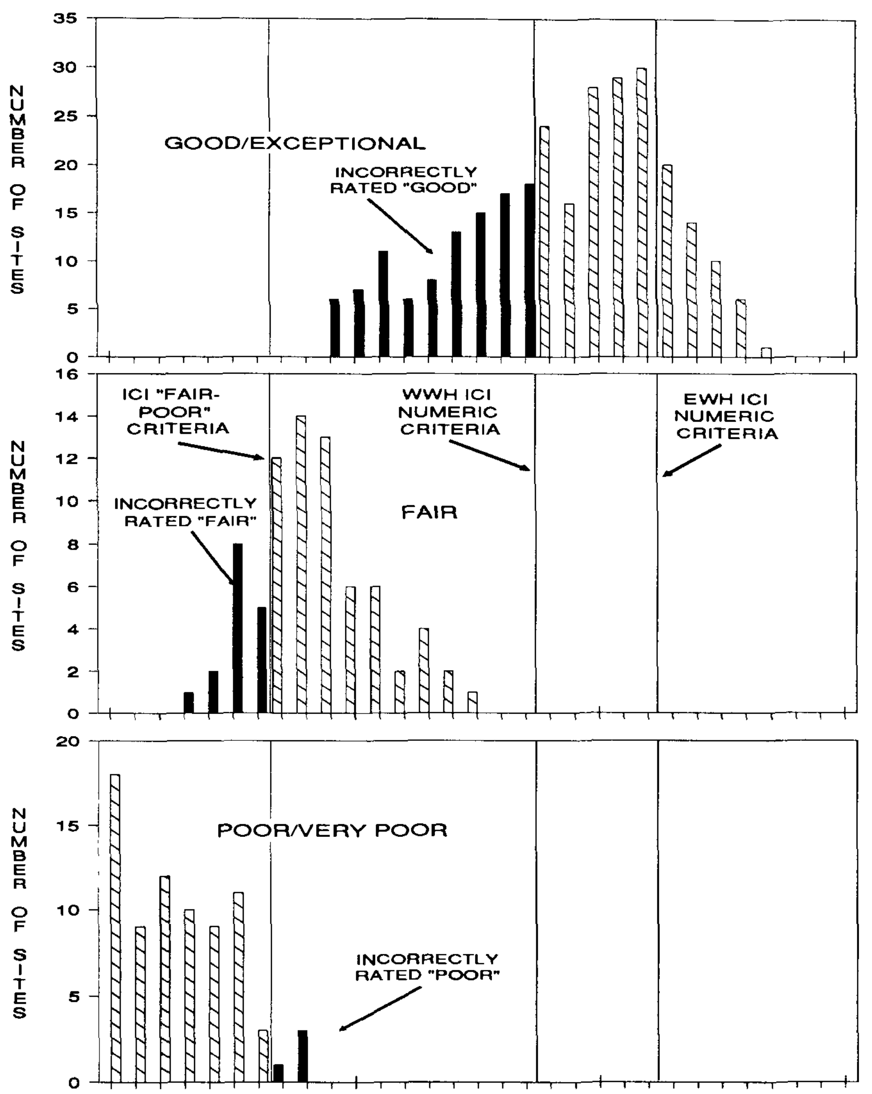

Figure 7.—Frequency distribution of ICI scores for more than 400 sites rated as Exceptional/Good, Fair, and Poor/Very Poor using the qualitative, narrative biocriteria developed in 1980 compared to the ICI biocriteria based on the regional, reference site approach. The solid bars are sites that were incorrectly rated by the narrative system vs. the ICI scoring derived from a numeric, regional, reference site system.

The predominant error orientation of the narrative approach was to rate sites as better than they were as determined by a calibrated evaluation mechanism. While it may seem premature to assume that the ICI is more accurate, the fact that it is a multimetric evaluation mechanism designed to produce the essence of the narrative system, but with greater precision, and that it extracts information directly from the regional reference sites argues in favor of the ICI.

The narrative evaluation system, on the other hand, relies on the best professional judgment of the biologist examining a completed sample sheet by eye aided by single dimension attributes such as number of taxa and a diversity index. An initial evaluation of Ohio EPA fish community narrative evaluations and Ohio Department of Natural Resources Scenic Rivers volunteer monitoring data revealed similar but more pronounced biases. Hilsenhoff (1990) recognized that such coarse assessments, although less expensive, result in less precise and discriminating results.

The impact of the type of biological evaluation used can be quite striking, particularly in broad-scale assessments such as the biennial 305b report. In the 1986 Ohio 305b report, judgments about use impairments were based largely on narrative biological assessments. Statewide results included:

- Nonattaining waters at 9 percent,
- Partial attainment at 30 percent, and
- Full attainment at 61 percent.

In 1988, Ohio used quantitative, numerical biological criteria employing multimetric evaluation mechanisms based on a regional reference site derivation process. The waterbodies assessed in the 1986 305b report were re-evaluated in addition to the new assessments completed in 1987 and 1988; 44 percent of the waters were in nonattainment with only 34 percent fully attaining.

The marked increase in nonattaining waters between 1986 and 1988 was not wholly a result of poorer water quality but rather the different methods employed. Not only were the numerical criteria capable of more accurately assessing impairment, but the types of environmental problems that could be assessed were expanded to include more subtle nonchemical and nontoxic chemical impacts. In this example, the same data were analyzed in different ways. The aforementioned discrepancies would likely have been further compounded if methods of data collection had also changed.

This example not only illustrates the usefulness of the regional reference site approach, but also the importance of making the correct initial data collection decisions early in the monitoring process. A misplaced preoccupation with minimizing the cost of data collection could have some unfortunate consequences later in the process.

5. Does the collection and analysis of biosurvey data delay NPDES permits?

This question is more rhetorical than real since the lack of ambient environmental data seldom supersedes a regulatory agency's schedule for issuing National Pollutant Discharge Elimination System (NPDES) permits. However, if the proper organization of monitoring and NPDES issuance is achieved, neither need be a major concern.

Recently, Ohio implemented a rotating five-year basin approach to monitoring and NPDES permit reissuance. This approach allows enough lead time to ensure that biosurvey and other important information such as bioassays, chemical data, and Form 2C are available in time to support the drafting and issuance of NPDES permits. In Ohio, biosurvey data are deemed necessary for only a fraction of the NPDES permits issued. Prioritization and direction of resources are also important since resources are insufficient to monitor everywhere.

Within the five-year approach, some issues are evaluated every five years whereas other issues are evaluated on a 10-year or even 15-year rotation. Inevitably "fire drills" do occur and are responded to as needed. Ohio EPA can respond to specific requests—including both fish and macroinvertebrate field sampling, laboratory analysis, and data processing according to Ohio EPA protocols and procedures—on a one-week turnaround schedule (Ohio Environ. Prot. Agency, 1987, 1989b).

Conclusions

While the value and need for biological assessment have recently been recognized (U.S. Environ. Prot. Agency, 1990), many questions remain concerning the details of deriving and including biological criteria in State water quality standards regulations. Ohio EPA has attempted to answer five of the most commonly asked questions about the States' biological criteria. Some of the most important findings efforts have been:

- Biological criteria have a broad ability to assess and characterize a variety of chemical, physical, and biological impacts and detect cumulative impacts;
- Biological and integrated chemical-toxicity assessments can serve a broad range of environmental and regulatory programs, including water quality standards, NPDES permitting, nonpoint source management and assessment, natural resource damage assessment, habitat protection, and any other surface water efforts where aquatic life protection is a goal;
- Integrated approaches to surface water resource assessment yield more environmentally accurate results;
- Nontoxic and nonchemical causes of impairment predominate in Ohio; and
- Narrative and numerical-based biological assessment approaches differ widely in precision and accuracy.

The latter finding seems particularly important given the policy concerns about use of biosurvey data and biological criteria in the regulatory process. EPA favors an independent approach in the application of chemical-specific, bioassay and biosurvey results (U.S. Environ. Prot. Agency, 1990). Others have proposed a weight-of-evidence approach, where the weight given to any one assessment tool is considered site-specifically in a risk-based management process (Ohio Environ. Prot. Agency, 1989c). Based on the results of the narrative-numerical comparison, it would seem prudent to require independent application for narrative-based biological assessments, given the error tendencies of that approach. However, a discretionary use of the weight-of-evidence approach could be granted for States that have a fully developed numerical approach based on regional reference sites and multiple organism groups.

States are required to include at least narrative biological criteria in their water quality standards by 1993, but development of a numerical approach is not mandated. However, basing policy discretion on the strength of the biological assessment approach could serve as an incentive for States to develop a numerical system if they want to use the weight-of-evidence policy. This would not only result in a more powerful and environmentally accurate assessment tool for the individual States and EPA but would provide maximum flexibility within the entire water program. Thus, development of the more detailed numerical system would benefit both EPA's and individual State's environmental awareness and program flexibility.

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Biological Monitoring in the Wabash River and Its Tributaries

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Introduction

Annually since 1967, the Department of Biological Sciences at DePauw University has studied the aquatic communities of the middle Wabash River and its tributaries (Gammon, 1971, 1973, 1976, 1982; Teppen and Gammon 1975; Gammon et al. 1979). Initial assessments of thermal effects at two power plants were expanded in 1973 to include 160 miles of the main stem. In recent years, we have documented sharp improvements in the Wabash River itself but have simultaneously observed marked negative changes from agricultural activities in the tributaries (Gammon et al. 1990).

Direct current electrofishing has proven to be most effective collection method for the greatest number of large fish species in the Wabash River. Fish are sampled three times each summer from 63 stations, each 0.5 km (0.31 miles) long, which are generally sited in relatively fast-moving water with good cover and depths of 1.5 m or less. Although some macrobenthic, periphyton, and phytoplankton populations are studied, most research has focused on the fish community.

Major Findings

Fish Communities

A healthy fish community is one with both an abundance of individuals and a high diversity of species; therefore, we formulated a composite index of well-being (I_{wb}) to quantitatively represent the fish communities from electrofishing catches (Gammon, 1980). This index is calculated as:

$$I_{wb} = 0.5 \ln N + 0.5 \ln W + Div._{no.} + Div._{wt.}$$

Where N = number of fish captured per km
W = weight in kg of fish captured per km
$Div._{no.}$ = Shannon diversity based on numbers
$Div._{wt.}$ = Shannon diversity based on weight

High I_{wb} values correspond with excellent fish communities and low values with poor fish communities (Table 1 and Fig. 1). Therefore, the I_{wb} values are remarkably similar to the average number of species taken at each site. In recent years, the long-term studies have shown some rather spectacular improvements.

From 1973-75 to 1985-87, the overall fish community in the Wabash River improved markedly (Fig. 2). The upper reaches went from fair to good/excellent, while the lower reaches improved from poor to fair. From 1974 through 1983, the combined catch rate of sport fishes averaged slightly more than 2.0 per km, and since 1984, the average catch rate has quadrupled.

Most species populations, except for carp and gizzard shad, exhibited noticeable gains. Many other species of fish also increased, especially in the upper river. Populations of channel catfish, flathead catfish, sauger, spotted bass, mooneye, goldeye, northern river carpsucker, blue sucker, and drum, species that reproduce and live in the main stem, increased greatly in density. White bass and walleye, which enter the main stem from offstream reservoirs, also increased significantly, as did

Table 1.—Community parameters and qualitative evaluations of fish communities.

PARAMETER	EXCELLENT	GOOD	FAIR	POOR
		Community Parameters		
Iwb	> 8.5	7.0–8.5	5.5–7.0	< 5.5
Av. No. Spec.	> 15	8–15	5–8	< 5
No/km	> 100	60–100	25–60	< 25
Kg/km	> 50	25–50	15–25	< 15
*Div. (no.)	> 2.2	1.7–2.2	1.3–1.7	< 1.3
**Div. (wt.)	> 2.0	1.5–2 0	1.1–1.5	< 1.1
Even (no)		0.75–0.90		
Even (wt.)		0.70–0.80		
		*Sport Fish****		
No./km.	> 20	12–20	4–12	< 4
		Trophic Composition		
% wt. Piscivores		15–30		
% wt. Insectivores	> 30	15–30	5–15	> 5
% wt. Herbivores	< 10	10–20	10–20	> 20
% wt. Detritivores	> 5	2–5	1–4	< 1

*Shannon diversity based on numbers
**Shannon diversity based on weight
***Centrarchid basses, white bass, flathead catfish, channel catfish, sauger, walleye, sunfish, and crappie

smallmouth bass and longear sunfish, species that enter from clean tributaries.

At the same time, populations of carp and gizzard shad have decreased. (The decline in the latter may be related to the increased predator pressure from expanded piscivore populations.) Some populations (blue sucker, mooneye, and spotted bass) have expanded into previously unoccupied areas of the river. There was also an average size increase for many species, which has opened questions about greater longevity and/or faster growth that remain to be explored.

These recent improvements in the fish community may have resulted from a combination of long-term 50 percent reduction in biochemical oxygen demand (BOD) loading, and a low-flow summer in 1983, which facilitated good reproduction and survival through the first year. Reductions in BOD are probably related to the overall effort to improve industrial and municipal waste treatment. An acute 25 percent reduction in potential agricultural loadings to the river during the U.S. Department of Agriculture's 1983 PIK program also may have augmented the change.

Water Quality Data

In addition to examining long-term changes in fish population abundance, community composition, and geographic distribution, our studies helped to distinguish natural from human-induced perturbations, locate problem areas in the river, and evaluate effects of changes in operating procedures at point sources of pollution.

Good reproduction and survival through the first year of life in fish species that reproduce in the main stem are related to low summer flows during June and July. Population levels of many species were lowest in 1983 following several years of higher than normal flows. By 1986, population levels had increased to their greatest extent.

Dissolved oxygen (DO) modeling has been of great value in interpreting spatial population differences (HydroQual, 1984). There appears to be an inverse relationship between the quality of the fish community and DO levels. Using the DIURNAL model, the DO deficit during periods of low flow in the upper river was projected at approximately 2.0 to 2.5 mg/L, which increases to approximately 4.0 mg/L in the lower reaches.

Phytoplankton respiration is responsible for about 50 to 60 percent of the DO deficit in the upper reaches and about 70 percent in the lower reaches. The second largest DO sink is BOD, which enters the river from multiple point sources and accounts for about 10 percent of the DO deficit in the upper river and over 15 percent in the lower reaches. Sediment oxygen demand is also important, especially in depositional pools.

Organic materials, including phytoplankton, may indirectly affect the fish community by reducing dissolved oxygen concentrations in some parts of the river (Parke and Gammon, 1986). During low flow in summer, interactions occur between river morphology, large diatom populations sustained by high nutrient inputs, and thermal loading from an electric generating station, to produce low DO in a six-mile section of river dammed by gravel from Sugar Creek. When flows diminish to about 1,500 cubic feet per second, there is a sharp increase in phytoplankton density, with chlorophyll *a* increasing from about 160 µg/L to nearly 230 µg/L.

As the water passes through the ponded segment, significant amounts of suspended solids settles to the bottom, with chlorophyll *a* decreasing to less than 150 μg/L and Secchi transparency increasing as suspended materials settle out. Total suspended nonfiltrable solids decrease from about 80 mg/L to about 50 mg/L, and sediment oxygen demand increases. Depressions in DO were severe enough to kill fish in 1983 and 1986.

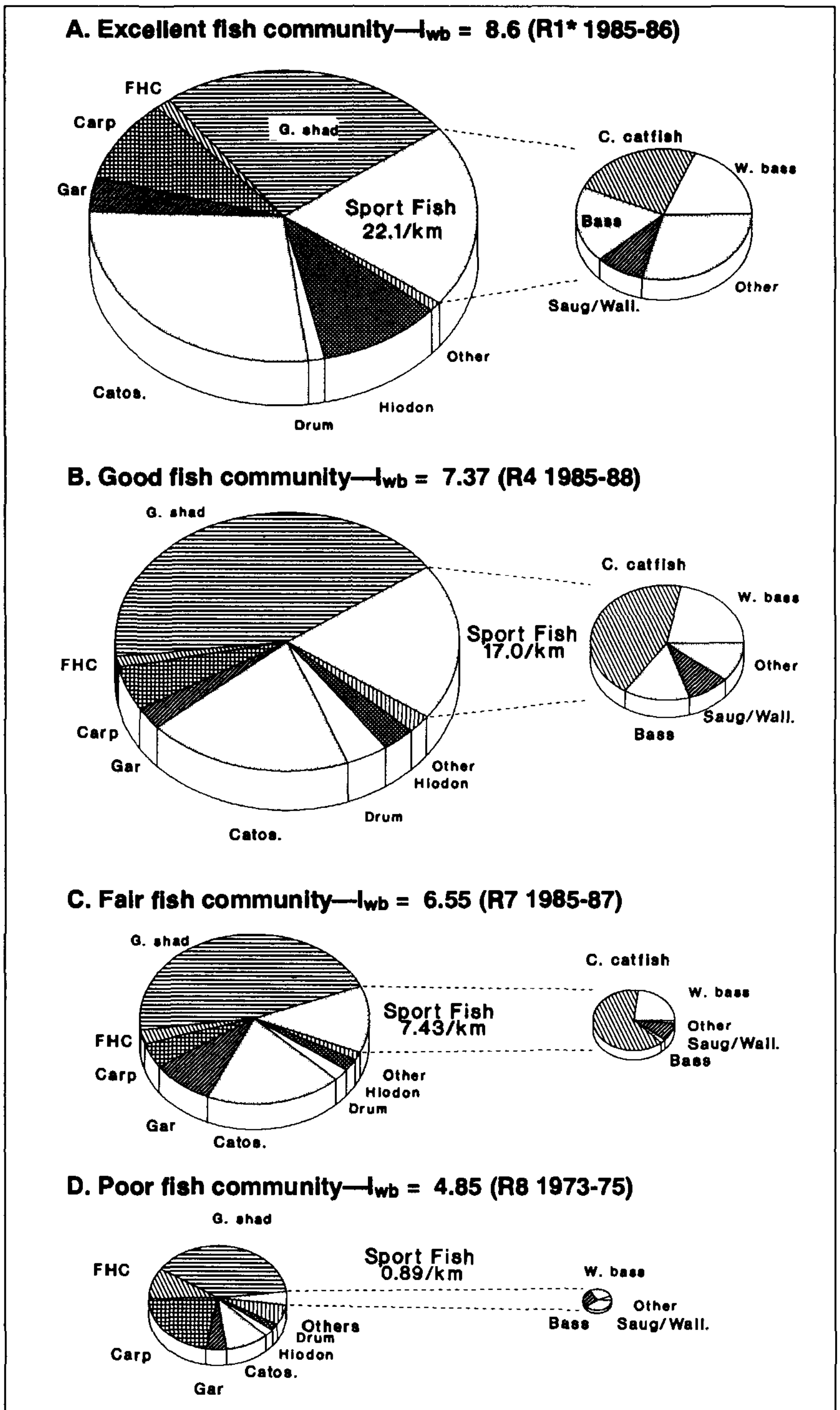

Figure 1.—Examples of "excellent," "good," "fair," and "poor," fish communities of the Wabash River. (R* = reach.)

Biological Data

The biological data are also valuable when evaluating effectiveness of waste treatment procedure changes. For example, when an electric generating station began operating cooling facilities continuously at ambient river water temperatures of 78°F, the I_{wb} improved in that reach, although it declined in all other reaches. Furthermore, smallmouth buffalo, redhorse, blue sucker, and sauger, fish species that had not been common for many years, returned to the area.

The fish community was usually quite stable during the summer and into fall, so sampling variability usually was not dependent upon sampling timing. However, rather large changes resulting from stress sometimes occurred within a few weeks (Gammon and Reidy, 1981). Based on the changes in fish communities we have seen, monitoring frequency should be no less than every three years. Major shifts in population size and community structure would be missed at longer intervals.

Nonpoint Source Pollution

Seining and/or various electrofishing techniques used separately or in combination provide comprehensive way to directly assess fish communities in smaller streams (Orders I-V). Also, benthic invertebrates are used extensively. Catches of fish at multiple stations are converted to Index of Biotic Integrity (IBI) scores (Angermeier and Karr, 1986; Karr 1987).

The IBI also functions well in assessing the effect of nonpoint source pollution on stream fish communities because 5 of the 12 metrics include species sensitive to sediment pollution. Sometimes historic data can provide information about changes in stream environments.

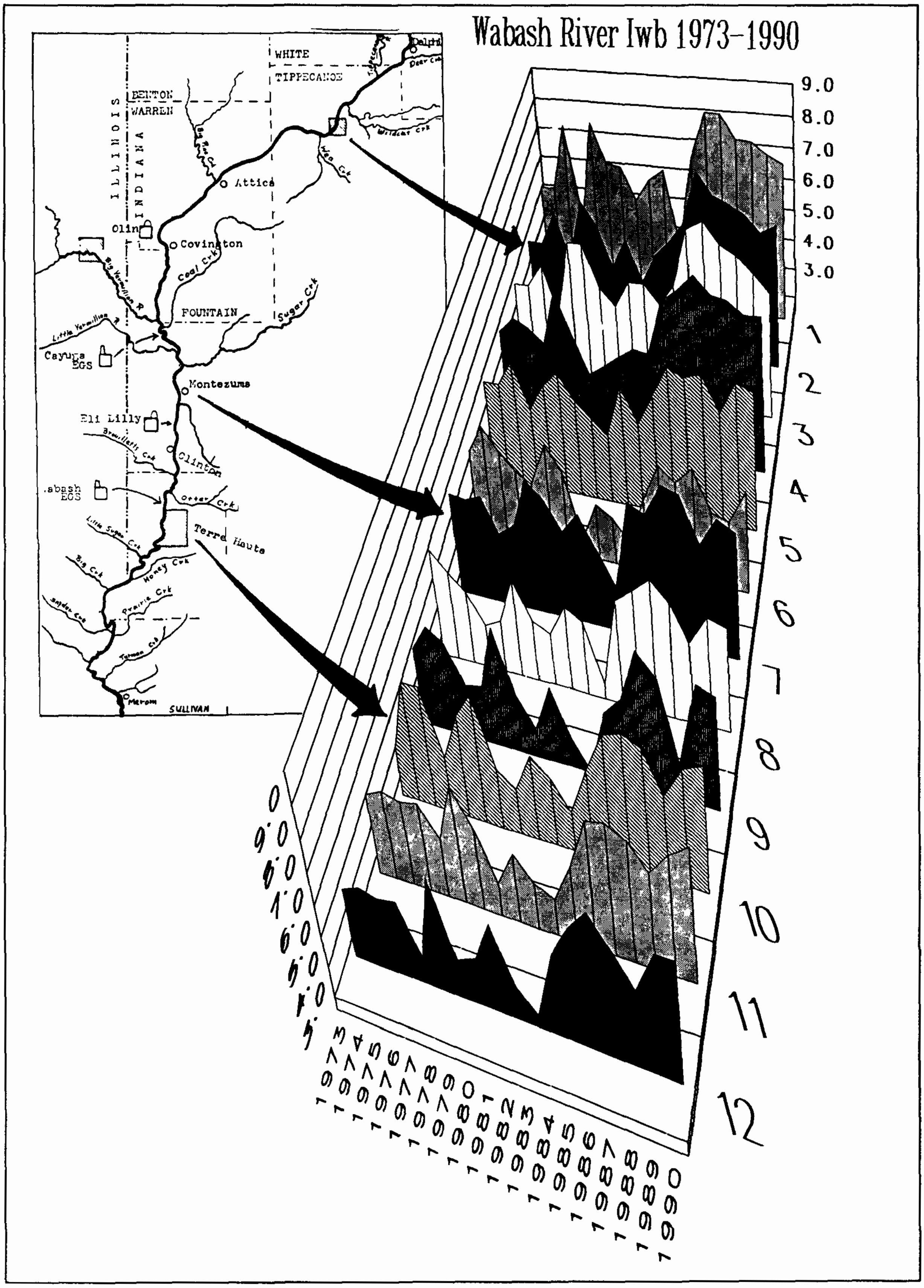

Figure 2.—Spatial and temporal changes in the fish communities of the Wabash River.

Most small midwestern streams are affected by agriculture through periodic nonpoint source delivery of soil and chemicals from fields as well as by sporadic spills of fertilizer, agricultural chemicals, and animal wastes. However, because they are small and abundant, these streams are rarely monitored for chemicals.

Big Raccoon Creek and some of its tributaries supported good fish populations 25 years ago (Gammon, 1965), but darters, sunfish, and bass disappeared sometime before 1981. From 1981 through 1989, three electrofishing collections, each at eight stations, were made to biologically monitor a landfill (Gammon, 1990). The landfill has not measurably affected the fish community, but agriculture certainly has. This data set is interesting because it demonstrates community changes in agricultural watersheds as affected by natural weather and flow patterns.

Figure 3 portrays the changes in mean IBI and I_{wb} values in the Wabash River from 1981 to 1990. Variability over time is quite striking, with lows in 1981 (IBI = 36.5; I_{wb} = 5.53) increasing to highs in 1988 (IBI = 50.5; I_{wb} = 8.83), which were associated with extremely low flows and a prolonged drought. Fish were undoubtedly more concentrated and vulnerable to capture than usual.

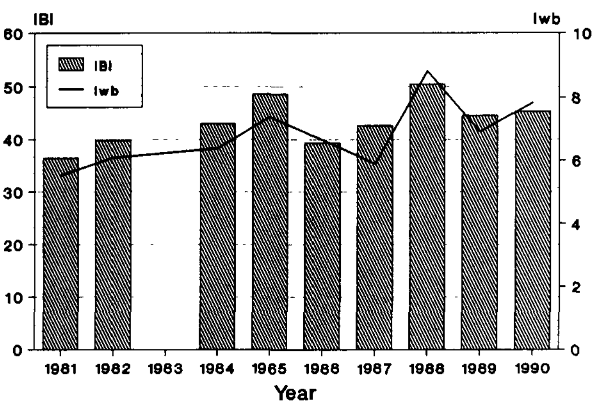

Figure 3.—Changes in the fish communities of Big Raccoon Creek from 1981 through 1990 as measured by I_{wb} and IBI.

The low community values from 1981 through 1984 probably resulted from poor reproduction and survival during unusually high water in the summers of 1979, 1981, and 1982. Darters, sunfish, and bass were virtually absent during those years (Fig. 4); however, there was a corresponding increase in the frequency of darters, sunfish, and bass with the increase in IBI values in 1985 and 1988.

This biological monitoring approach applied to other stream systems provides evidence that some, perhaps many streams in predominately agricultural watersheds have lost darters, sunfish,

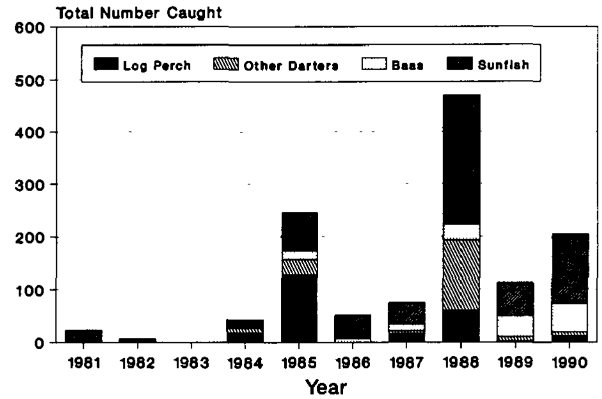

Figure 4.—Differences in the annual catches of darters, sunfish, and bass in Big Raccoon Creek from 1981 through 1990.

smallmouth bass, and sensitive minnows because of aggregate agricultural impacts in recent years (Gammon et al. 1990). The greater the agricultural intensity, the lower the IBI values (Table 2 and Fig. 5).

Weather and stream discharge regimes are especially important determinants of nonpoint sources. A succession of wet years with high, turbid water may cause poor reproduction and decimate species populations that are merely marginal during good years. Conversely, a run of dry years may favor good reproduction and permit a certain degree of

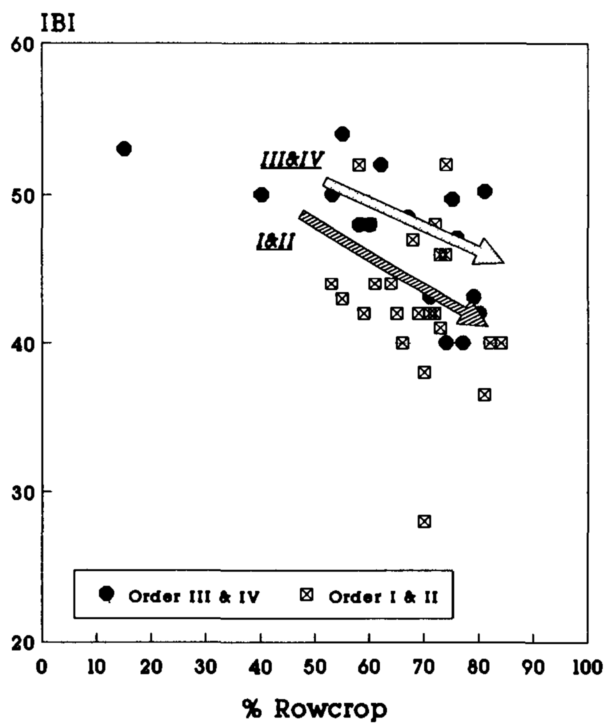

Figure 5.—The influence of rowcrop agriculture on fish communities. Orders I and II are small headwater streams; Orders III and IV are larger streams.

Table 2.—Agricultural land use and IBI values for fish communities of some Indiana streams.

STREAM	STREAM ORDER	DRAINAGE BASIN AREA km²	(mi²)	% ROWCROP	IBI
		Sugar Creek System			
Main Stem					
Above Darlington	III	829	(320)		47.1[a]
Darl. to Crawfordsville	IV	1318	(509)	75	49 7[b]
Crawfordsville to mouth	IV	2100	(811)	60	48 0[c]
Tributaries					
Rush	I	42 2	(16.3)	64	44
Sugar Mill	II	197.4	(76.2)	69	42
Indian	II	65.5	(25.3)	70	38
Rattlesnake	III	81.3	(31.4)	59	52
Offield	II			59	42
Black	II	90.4	(34.9)	66	40
Walnut Fork	II/III	117.3	(45 3)	71	42
Little Sugar	II/III	117.6	(45.4)	69	47
Lye	III	203.8	(78.7)	82	36.5
Wolf	II	65.8	(25.4)	74	52
Prairie	III	127.9	(49.4)	70	28
		Big Raccoon Creek System			
Main Stem					
Montgomery Co.	III	251 0	(96.9)	80	42[d]
Ramp Crk to Putnam Co	III	365.2	(141)	71	43 1[e]
Tributaries					
Cornstalk	II	52.6	(20.3)	72	41
Haw	II	72 5	(28.0)	73	42
Ramp	III	85.7	(33 1)	62	52
		Big Walnut Creek System			
Main Stem					
Above US 36	IV	357.6	(138)	81	50.2[f]
US 36 to Greencastle	IV	575 0	(222)	67	48 5[g]
		Eagle Creek System			
Main Stem—upper	III	74.1	(28.6)	74.4	48
Tributaries					
School Branch	I	22.7	(8.7)	73 6	46
Fishback	II	53.8	(20 8)	65.3	42
Little Eagle	II	75.9	(29 3)	72.4	46
Finley	I	25 2	(9.8)	72.1	48
Mount's Run	II	41 2	(15.9)	59.7	48
		Eel River System			
Main Stem	IV	2148	(814)	79.0	43.1[h]
Tributaries					
TwelveMile Creek	II	138	(53.1)	60	44
Paw Paw Creek	III	142	(54.9)	75	40
Squirrel Creek	III	103	(39.9)	75	40
Beargrass Creek	II	60	(23.2)	82	40
Sugar Creek	II	80	(30.7)	84	40
Blue River	III	209	(80.6)	79	42
		Stotts Creek System			
Main Stem	IV	155 6	(60.1)	58.4	48
North Fork					
lower	III	56.7	(21.9)	55.0	54
upper	II				43
South Fork					
lower	III	87.3	(33.7)	53.4	50
upper	II				44
		Miscellaneous Streams			
Rattlesnake Creek	III	65 2	(25.2)	15	53[i]
Stinking Fork	III	70 7	(27.3)	40	50[j]

[a]Mean of 7 stations above Darlington (1988)
[b]Mean of 4 stations between Darlington and Crawfordsville (1988)
[c]Mean of 12 stations between Crawfordsville and the mouth (1988)
[d]Mean of 3 stations (1983)
[e]Mean of 8 stations over 8 years (1981 through 1989)
[f]Mean of 8 stations (1979 through 1984)
[g]Mean of 8 stations (1979 through 1987)
[h]Mean of 15 stations (1990)
[i]Mean of 2 stations (1979 through 1981)
[j]Mean of 4 stations (1984)

recovery. Lastly, less disturbed tributaries can serve as refugia for replenishing a degraded main stem during favorable periods. The reverse may also occur. Likewise, normally degraded tributaries may sometimes enjoy rejuvenation because of a healthy main stem.

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Biological Criteria Issues in the Great Lakes

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The National Wildlife Federation's Great Lakes program, based in Ann Arbor, focuses on restoring the ecological health of these waterbodies. Over the last eight years, we have worked extensively to implement the United States–Canada Great Lakes Water Quality Agreement. The Program for Zero Discharge, a binational effort between this office and the Canadian Institute for Environmental Law and Policy, takes its name from the policy goal contained in that agreement: that, for persistent toxic substances, the government's policy should be zero discharge and virtual elimination of those substances.

I want to expand the definition of biological criteria in water quality standards to include two additional elements: wildlife criteria and ecosystem indicators. Wildlife criteria are simply numerical criteria for specific chemicals that are based on preventing toxic effects in wildlife species as opposed to protecting aquatic life or human health. In addition to establishing criteria to protect against cancer and effects on aquatic life, States should create specific criteria to protect wildlife. Wisconsin has already adopted a procedure to develop and apply wildlife criteria in its water quality standards.

The National Wildlife Federation has taken the basic foundation that Wisconsin developed and improved it. We have generated a model wildlife water quality standards proposal and are advocating its adoption by all the Great Lakes States. Since the passage of the Great Lakes Critical Program Act, which stipulates that guidance be developed for water quality standards to protect human health, aquatic life, and wildlife, the Great Lakes States and the U.S. Environmental Protection Agency (EPA) are required to adopt wildlife criteria. That work is underway in EPA's Great Lakes Water Quality Initiative.

The second element that should be included is what we in the Great Lakes refer to as "ecosystem indicators." The history of toxic contamination in the Great Lakes has been one of devastating effects on wildlife. Recently, the effects over the last 20 to 30 years have been documented.

In 1989, the Conservation Foundation published *Great Lakes, Great Legacy?*, which summarized many of the problems and surveyed all of the available literature and some unpublished reports. The Foundation has researched 16 animals, including reptiles, fish, birds, and mammals—all species at the top of the Great Lakes food chain. The scientists found a wide range of effects that ranged from outright mortality to birth defects: cormants with crossed bills, turtles without tails; developmental defects: lake trout swimming upside down; and other, subtle changes, including feminization: male herring gulls acting like females as a result of the similarity in the chemical structures of some of the Great Lakes toxicants and female hormones.

Under the Great Lakes Water Quality Agreement, at least one ecosystem indicator is supposed to be developed for each of the Great Lakes. So far, one has been proposed for Lake Superior—lake trout. There is a specific number of kilograms per hectare of stable, self-producing lake trout stock that should be in Lake Superior as a result of restoration efforts.

Why do we need biological and wildlife criteria and ecosystem indicators? The following three reasons strike at some of the fundamental weaknesses in our water quality standards and related programs. They also will suggest some of the ways these procedures should be used in regulatory programs.

The first problem with our programs is their nearly complete *reliance on cancer criteria*. The way we look at it, many of our water quality standards, pollution control programs, and effluent limitations are supported by a one-legged stool, and that one leg is relying on cancer criteria. If wildlife criteria were developed, they would provide a broader base of support (the second leg) for many of these programs. The third leg is criteria to protect against human reproduction and developmental effects.

Cancer risk assessment has recently come under attack from a variety of sources, notably the pulp and paper industry whose aggressive and sometimes successful attack on establishment of dioxin standards in several States has challenged the potency of dioxin, based on low-dose extrapolation from laboratory animal studies. Our work in developing wildlife criteria suggests that, had wildlife criteria been promulgated and developed, they would show that standards to protect wildlife and other inpoints are probably lower than cancer risk assessment criteria.

Implementation of cancer criteria and regulatory programs based on cancer have also come under attack recently. The National Wildlife Federation is seeing increased use of dilution for carcinogenic substances in the Great Lakes, and we're very concerned. EPA's draft technical support document advocates that, for carcinogens, an increased dilution might be considered when assessing the dilution capacity of stream flow. Instead of looking at low-flow stream calculation, such as 7Q10, EPA has suggested that harmonic mean flow might be used for dilution capacity. The result would be greater discharges of mass loads of carcinogens into the receiving waters.

The second fundamental weakness that we see in water quality standards programs that can be corrected by biological and wildlife criteria is a *focus solely on point sources*. Wildlife in the Great Lakes are sending us a clear message: the ecosystem is still contaminated. Wildlife criteria, ecosystem indicators, and biological criteria can tell us sources—other than point sources—of these problems. Point sources are still important; however, restoring ecological indicators for the health of the Great Lakes will require more than just cracking down further on point sources. We must also control contaminated sediments, atmospheric deposition, and polluted runoff. Not only can biological and ecosystem indicators tell us which waters are polluted and help us set priorities for the cleanup, but they can define precisely how much cleanup is required—what reductions in the total mass of pollutants coming into a waterbody are required to restore its health.

The third problem is a *focus on the area immediately downstream from a source of pollution*. This is manifested by using dilution, wherein our regulatory programs require that numeric criteria be met at the edge of a mixing zone. This approach fails to consider the long-term, ecosystem-level impacts—either by adding to contaminated sediment problems or by resulting in increased bioaccumulation in the food chain—of the total mass load of these substances.

It has been suggested that the bald eagle should be used as an indicator species for ecosystem restoration in the Great Lakes. We support this work, which is progressing. Right now, there are increased populations of bald eagles because DDT has been banned. However, these birds are not able to reproduce on the shores of the Great Lakes as successfully as birds inland. In fact, blood samples from bald eagles nesting on the shores of the Great Lakes show the highest contaminant levels of any in North America, which tells us that the Great Lakes ecosystem has not been restored.

The bald eagle could be a visible and powerful reason to restore the Great Lakes. It will be easier to motivate the public to fund and support programs to clean up contaminated sediments and solve other problems if we talk about bringing back the bald eagle—rather than lecture scientifically about reaching some infinitesimally low number of parts per quadrillion in the water column.

Finally, I want to throw out one caution about the use of biological criteria. Biological criteria are a welcome improvement, and EPA's guidance material provides a lot of detail about their development. However, I'm concerned about how these criteria might be used.

Biological criteria basically look at the number and diversity of species and the number of individuals, but they are primarily focused on aquatic organisms. In the Great Lakes, we're concerned about what might be eating those aquatic organisms—whether they're sport anglers, bald eagles, or other predators at the top of the food chain. It would be a gross misuse of biological criteria if they were used to rationalize increased pollution because they did not indicate that a particular discharge level was causing an effect.

Considerations in the Development and Implementation of Biocriteria

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Introduction

The past decade has seen a rapid expansion in the number of tools available for assessing water quality. All of us in water quality protection are encouraged by improvements in the ability to distinguish between impaired and unimpaired aquatic communities and identify causes of impairment. Clearly, it is in everyone's interest that the best science possible be brought to bear on identifying water quality problems and eliminating them.

The paper industry has long held that data on the health of the resident aquatic community are critical to obtaining a true assessment of water quality. Indeed, a recent call for such information from just the chemical pulp producers yielded over 200 studies encompassing 45 mills and more than 40 receiving waters (Natl. Counc. Pap. Indus. Air/Stream Improv. 1989) Surface water ecosystems are far too complex to be modeled adequately by laboratory bioassays or estimates of specific chemicals' significance that are based largely on data from these bioassays. Data on the resident aquatic ecosystem can provide a much-needed interpretive framework for that generated under more controlled laboratory conditions (Gellman, 1988). The need for a real world interpretive framework will only increase as scientists develop increasingly sensitive methods for measuring subtle and sometimes insignificant effects on organisms.

Development of Biocriteria

Over the past three years, the National Council of the Paper Industry for Air and Stream Improvement (NCASI) has been closely following biocriteria development in two States. Our involvement has included comments on draft biocriteria and participation in technical committees that provide input to the States' agencies on biocriteria development. We consider the areas addressed in the next sections to be of greatest concern.

Document All Steps During Biocriteria Development

As biocriteria are developed, a number of decisions must be made, particularly in the choice of reference sites; communities sampled; sampling methods, time, and frequency; metrics (numerical expressions of the structure or function of the aquatic community, such as the number of species); and biocriteria expression. The process used to select each of these parameters should be extensively documented so all interested groups can follow the rationale and methodology behind the proposed criteria, thus promoting an understanding of the process and allowing constructive comments on each step. Such documentation will also be helpful to new staff in regulatory agencies, the regulated community, and environmental groups or consultants. This information will also be the basis for identifying changes in methodology and related effects on the metrics.

We cannot overemphasize the importance of documenting previous methods and criteria development. The pulp and paper industry has compiled extensive in-stream survey data. In some cases, methods have changed significantly over time or were not documented adequately, which makes long-term assessment of the waterbody's character more difficult. The methods now being developed for biocriteria will provide a basis for identifying changes in waterbodies. Thus, methods for sampling and analysis of the data must be explained sufficiently to allow accurate assessment of changes.

Select Metrics that Are Free from Sampling Bias

When samples of a receiving waterbody are taken, the investigator will probably know which sampling stations are the control or reference stations and which the downstream or potentially impacted sites. Such prior knowledge, however, increases the potential for unintentionally biasing the results. Similar difficulties are encountered in determining off-flavors in fish. The American Society of Testing Materials method compensates for this bias by relying on a known control to judge the flavor of all treatment groups against and a hidden control to statistically compare all treatment groups. The hidden control almost always scores lower (poorer flavor) than the known control, although both samples come from the same exposure group.

There is little opportunity for hidden controls when comparing metrics during in-stream sampling. Therefore, the choice of metrics and differences between metric values used to indicate levels of impact must account for variability of the metric and any unintentional bias. The effect of this type of bias is probably minimal compared to other sources of variability in a large majority of metrics. However, if the number of organisms required to change a metric value is low, this possibility increases.

The number of anomalous fish found at each sampling location is an example of a metric that may be changed by an extremely small difference between locations. Since the detection of diseases or abnormalities also tends to be more subjective, the practitioner must be cautious when using this type of metric to define levels for determining differences between sites.

Our purpose in choosing this metric was not to seek removal of this or any other proposed method of describing impacted or reference sites. Rather, we hope that as these methods are used, some attention will be paid to the possibility of this type of bias. Perhaps studies should be designed to determine if any given metric can be influenced by unintended bias.

Select Metrics that Describe Reference and Impacted Sites Adequately

Because biocriteria are used to distinguish between reference sites and truly impacted sites, one must decide whether the criteria should include all or just some of the original reference sites and, if a percentage of reference sites falls below the criteria selected, how that percentage should be selected.

Professional judgment will be necessary to select the criteria and determine the percentage of reference sites that meet them. However, we are concerned when more than 10 percent of the reference stations fail to meet the selected criteria, particularly if a reexamination of the failed reference stations reveals no valid reason for eliminating them.

Therefore, we urge that criteria encompass at least 90 percent of the reference stations. If that cannot be accomplished, the metrics or the effect of other variables (such as habitat) should be reviewed further before criteria are established.

Identify Habitat's Influence on Metrics

Frequently when sampling the biota, data are taken on specific habitat variables. Habitat data are used in defining ecoregions and deciding whether to apply specific biocriteria to certain types of habitat (such as streams below dams, reservoirs, or estuaries). This use of habitat data should be encouraged as should more analyses of the effects of specific habitat variables on the chosen metrics within similar types of ecoregional waterbodies.

Since habitat generally has a major impact on the distribution and abundance of many organisms, it is also likely to affect the metrics chosen to describe reference areas. Closer examination of habitat variables can refine the levels of each metric, allowing better discrimination between reference and impacted sites and higher percentages of reference sites that meet the criteria. Studies examining the effect of habitat variables on metrics can be useful, particularly where values for a metric vary over a large range at reference sites.

Implementing Biocriteria

Possibly the most contentious issues surround the way criteria are used in making judgments about water quality. At least two approaches have been suggested. The first, sometimes termed "independent application" of the criteria, requires action if any criteria are not met. This approach assumes that, under all circumstances, all types of data associated with the various criteria are equally good measures of existing or potential water quality problems.

If, for instance, an organism fails to perform up to expectations in a bioassay, bioassay response must be improved even if irrefutable in-stream data document the presence of healthy and abundant populations of that organism and all others expected in similar waterbodies under pristine conditions.

In the second approach, all available data are examined and a judgment on water quality is made based on the "weight of the evidence." The weight-of-the-evidence approach is useful because it recognizes that:

- The quality of the information provided by chemical analyses, bioassays, river surveys, and eventually, physiological measurements, varies from site to site depending on a number of factors (many uncontrollable), and

- The relevance of the different types of data varies from site to site, again depending on a number of factors.

Statistical considerations are sometimes cited to support the independent application approach (U.S. Environ. Prot. Agency, 1990). Ideally, water quality criteria and the tests that support them would identify only real water quality problems. Unfortunately, statistical inference does not allow scientists to prove that something (in this case, water quality impairment) does <u>not</u> exist, which is sometimes used as justification for concluding that effects exist if any measures of water quality suggest that this is so.

While you cannot prove the absence of an effect, neither can you prove that an effect exists. What statistical methods provide is <u>evidence</u> of the presence or absence of effects.

Using methods of statistical inference, you can:

- Establish a null hypothesis: there is no effect on water quality, and an alternative hypothesis: there is an effect on water quality;

- Collect data to test the null hypothesis; and

- Either reject or do not reject the null hypothesis with a known degree of confidence.

If you reject the null hypothesis, you accept the alternative hypothesis: there is an effect on water quality. You do this with the knowledge that there is a certain probability that you are wrong; that in reality, there was no effect but you declared there was. This probability is known as the "significance level" of the test, sometimes termed the "false positive rate."

Failure to reject the null hypothesis is <u>not</u> the same as accepting it. A failure to reject the null hypothesis could mean that there is no effect or that there is one but it is too small to detect. The ability of a statistical test to correctly detect an effect of a certain size is known as the "power" of the test.

The power to detect effects increases as the number of tests in the experiment or monitoring program increases. Likewise, the probability of false positives also increases with increased testing.

If you are using methods incapable of detecting truly important effects (that is, they have low power), it may be reasonable from a purely statistical standpoint to conclude that there is an important effect if any one of the three methods applied independently allows you to reject the null hypothesis. When you do this, however, you must admit to the limited value of the test techniques in detecting effects and consider that every time an additional test is run, the probability of a false positive increases. To apply this rigorous statistical approach to the question of interpreting water quality assessment data, however, is to ignore several important considerations.

■ **First, this decision is based on the assumption that all effects on water quality are environmentally significant**. Clearly, some effects are small enough to be regarded as insignificant. If the statistical tests are powerful enough to detect differences larger than this, it is in fact possible to conclude, based on a non-rejection of the null hypothesis, that there has been no <u>environmentally significant</u> effect on water quality.

The measures of water quality that support the three types of criteria have been developed and implemented because they provide useful information both when they identify problems and when they do not. In other words, these are methods that allow statistical comparisons with a reasonable (albeit largely undefined) power. To ignore information suggesting an absence of an environmentally significant effect is to discard much of the value of these measurements.

■ **Second, the rigorous statistical justification for independent application of the three types of criteria assumes that the data developed to test for effects are of equal**

quality and relevance. Consider a case, for instance, where annual effluent analyses and simple low flow dilution calculations indicate that instream concentrations of chemical "X" exceed the respective aquatic life criteria, but copious unimpeachable studies involving the most sensitive organisms in the water quality criteria database suggest the lack of effects on these same organisms in effluent bioassays and the receiving water. A scientist might examine the quality and relevance of the available information and determine, based on the weight of the evidence, that the aquatic community is not significantly affected by the chemical. In this case, the scientist has made the professional judgment that the statistical significance of elevated chemical concentrations is not relevant considering the statistical and biological significance of the other available data.

In fact, in this case, EPA already uses the weight-of-the-evidence approach to the extent that it may determine that the national chemical criteria are not appropriate and that site-specific criteria should apply. This flexibility is an explicit recognition of the fact that, in some cases, certain types of information are more useful than others in making assessments of water quality. This flexibility to apply professional judgment in a weight-of-the-evidence approach should be extended to questions involving all three criteria.

■ **Lastly, possibly the most important obstacle to applying a weight-of-the-evidence approach to the implementation of water quality criteria is that it requires professional judgment.** This can cause discomfort among the regulated community because it will be the Agency's professional judgment that is most important in evaluating water quality assessment data. A weight-of-the-evidence approach can also be unsettling to the implementing agency, however, because it may force the agency to support its professional judgment—and this requires resources.

While this is an important concern, several factors should be considered. First, the Agency will be working within established frameworks for generating and evaluating the data associated with the different criteria; therefore, its professional judgment will not often be challenged in questions of whether individual criteria are being met at specific sites. Such questions will have been anticipated in development of the criteria and the regulations implementing them.

The need for professional judgment will arise primarily where data generated under the three different criteria appear contradictory. In developing the various criteria, EPA has attempted to establish that such disparities are not common and has presented data supporting this view. (U.S. Environ. Prot. Agency, 1990). If this is the case, disagreements involving disparities will not be common.

In any event, in those cases where disparities develop, the system should provide incentives for resolving the apparent disparities before regulatory action is taken. A weight-of-the-evidence approach would provide such incentives yet would leave with the Agency the authority to determine when the information was adequate to initiate regulatory action.

Summary

The use of data on the health of resident aquatic biota is critical to water quality assessment programs. Such information provides a much-needed real world interpretive framework for other data generated under less realistic conditions. The biocriteria program could be helpful in providing standard methods for developing data on the health of resident aquatic biota and a well-reviewed framework for interpreting such data.

The biocriteria development process would benefit from better documentation of all steps during biocriteria development; a better understanding of the potential importance of unintentional bias and selection of metrics that are as free as possible from such bias; metrics that adequately discriminate reference sites from impacted sites; and a better understanding of the influence of habitat on metrics and biocriteria.

The concept of independent application of all types of criteria is based largely on the fact that methods of statistical inference do not allow scientists to prove that water quality impairment does not exist. In fact, methods of statistical inference can provide important evidence that, if an effect exists, it is environmentally insignificant. In addition, the rigorous statistical justification for independent application of the three types of criteria assumes that the data developed to test for effects are of equal quality and relevance.

Making judgments about water quality using the weight of the evidence developed under all of the criteria acknowledges that the quality of the information provided by chemical analyses, bioassays, river surveys, and other methods as well as the relevance of the different types of data vary from site to site. EPA's data suggest that the three types of criteria will agree in the vast majority of cases. In those few instances where they do not, good science and public policy would suggest additional efforts to better understand the situation.

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Questions, Answers, and Comments

Q. *(Mark Pifher–Colorado Springs) As EPA indicated about the current controversy over its approach to biomonitoring, the Agency is demanding a single test, pass-fail approach for enforcement purposes. How will this biocriteria be incorporated into the enforcement process?*

A. We have a toxic program, a policy on how the tools are used. We have leaned more towards the weight-of-evidence approach to categorize the risk. One failure of doing one acute test is that risk would depend on one out of many tests. We have magnitude and duration considerations that should be considered for what the entity might do as far as further monitoring.

C. (Panelist) We keep coming back to the idea of an interpreter framework. There is no better framework for things like bioassay and chemical-specific data that are related to aquatic organism effects than information obtained from resident aquatic community data. You can use them to help make a judgment as to whether a single acute failure is significant to the environment. Technically and scientifically, that is a very valid thing to do.

Q. *(Nelson Thomas–EPA) I'd like to direct this one to Dennis Borton. You could do a real disservice to biocriteria by using a total weight-of-evidence program: Chris (Yoder) had numerical criteria failing 2.8 percent of the time because they showed an impact when there wasn't one in the biological area. Ken Dickson presented at SETAC a 3 percent whole effluent toxicity, showing an impact when it wasn't measured in the biological test. However, biological tests are only a measure of the total ecosystem so they will vary. Placing the burden on the regulator to make this weight of evidence really slows the process down and does not explore the individual measures.*

A. (Dennis Borton–NCASI) We see relatively little disagreement with the three different measures. I wonder why looking at all the measures to make a judgment about water quality would slow the process down. Also, while we talk about the weight-of-evidence approach, we don't really know how that method would work. We are acting here as scientists, without having lawyers looking over our shoulders telling us what's going to work and not going to work. Being a scientist, I would like to think that water quality assessments are too important to be left in the hands of lawyers. It's not the objective here to slow down a process but to provide the soundest technical scientific base for making a judgment about water quality.

C. (Chris Yoder) I'm amazed that we spend so much time dwelling on 3 percent of the problem when we don't dwell much on 50 percent of it. There are a lot of things out there that we take for granted and probably don't even know about that involve permitted exceedances—the NPDES system is one. I know our agency uses a significance of violation to take enforcement action. The question that was asked was one failure, not three out of four, not a failure of a chronic seven-day test. The result is a degree of significance—I don't think we can get around that.

Q. *Fifty percent meaning that there are situations where biocriteria show no impairment and yet some say chemical-specific criteria would show impairment? Is that the 50 percent you are talking about?*

A. (Chris Yoder) No, just the reverse of that.

Q. *That biocriteria show there is not, and chemical-specific criteria shows there is?*

A. (Chris Yoder) No, no. The 50 percent of the time we are getting biocriteria impairment that we are not seeing with the chemical-specific tools. I said that was an ambient example, but I think there are probably a number of permit examples we can explore when we have found devastation where the permit was thought to be in compliance. In large part, that comes from not knowing about sloppy housekeeping, not knowing about substances being released that weren't regulated. That is far too frequently the case than the opposite example we've been drawing on so far.

Q. *When dealing with headwater communities, when a city of 20,000 to 30,000 people is built in an agricultural area and they concrete everything, the stream will be affected simply as a result of the watershed changes (let's leave pollutants out). How do biocriteria in the reference points address this type of hydrologic modification?*

A. A lot of the impacts we pick up are nonchemical and sometimes there are very complex hydrology-related effects. To address that, we have different versions of these evaluation mechanisms calibrated for different-size streams; one happens to be for headwater streams, so we're comparing ample samples. A lot of situations you get into are what is attainable; sometimes you get into irretrievable conditions where you have to invoke the water quality regulations.

Q. *(Mary Jo Garreis–State of Maryland) In many cases, we are looking at streams that are receiving insults from either a number of point sources or a combination of point sources and nonpoint sources, such as in an urban situation or a suburban situation on an intensely developed watershed. In using these types of criteria, how do you zero in on an individual discharger or group of dischargers?*

A. What role do the dischargers play in the NPDES permit system? First of all, define what the attainable use is that derives the chemical design criteria that apply in the permit through the wasteload.

Q. *(Mary Jo Garreis) Suppose they're meeting all those chemical criteria?*

A. Well, you either don't have an adequate permit, or something else is unique to that situation, or you're not getting much accuracy in that situation.

Q. *(Mary Jo Garreis) What do these biocriteria do to increase my accuracy beyond helping identify that I have a problem? What information do they give me to identify that problem so that I can go back to permits or know what to look for in either point or nonpoint source situations? Stormwater is probably more difficult to manage than point sources and, in many cases, you don't have a "clean" system where you can do cleanup and comparisons. If we are going to talk about using biocriteria in terms of driving permits and improvements, then we have to help make them help us zero in on what must be done beyond identifying a problem. I would guess that many regulators and permit writers for a lot of impacted streams don't need biocriteria to tell them they have a problem; they need to know what they can do to get out of it, to make what they are doing better.*

A. I guess they have a problem because permit compliance alone isn't getting the job done. The answer to your question is difficult. In a lot of these situations where there is heavy urbanization, we've heard that the streams will never meet warmwater criteria. We can't prove that they ever will, but as an environmental regulatory agency and given the habitat conditions, we must be optimistic that they will some day or we wouldn't have grounds to demand improvement.

The other concern is that you can tell where there is departure but you can't find the problem. I would take issue with that statement; we are teasing out some very distinct patterns–say between a complex toxic impact versus a habitat impact versus a nutrient impact. Because we're using multimetric tools, there are other metrics outside of ones listed here that we can use as diagnostic indicators. It's not biocriteria alone, it's biocriteria in concert with the chemical criteria, habitat assessment, sediment chemistry, and the whole effluent toxicity that give the complete picture. On some of these problems, the information we get back sometimes is going to generate more questions than answers; however, is that a reason to throw up our hands and say these things don't help us do much? I don't think any of the other tools are answering those questions either.

C. Some of the things you presented do not necessarily address the direct regulatory usefulness of biocriteria, but they certainly help in identifying potential sources of impairments. I don't know if you want to expand on that.

A. (Chris Yoder) The fish community is often knocked because they move. And yet that's one of the benefits, because we have seen situations where a large segment of a community moved out before there was any obvious chemical reason to do so. They were responding to an early warning system and so vacated an area that subsequently went anoxic, two weeks later. It was not detectable chemically, but they knew something was going to happen or was happening where they were living. It's a responsive community and, as we learn more about it, we'll be able to do a better job of interpreting.

It's real easy to get so focused that you don't recognize that what you're looking at is part of larger system. We badly need whole watershed approaches, I think, not just a little stream segment. You must look at the whole system because it's all interacting. It doesn't matter how broad you get, there's still more coming in from the atmosphere and other areas as well.

C. The question about how biological criteria or wildlife criteria can be integrated into controls on sources is really the hub of this issue. It's obvious that biological criteria can be used to crack down on a point source permit, but what about situations when there are multiple sources? It is not the only answer, but there are some solutions to that problem in the Clean Water Act. Two are section 304(l) in the individual control strategies, that were to be developed for point sources and polluted waterbodies, and section 303(d), the total maximum daily load approach. In polluted waters that are exceeding water quality standards, either one of those sections can be used to trigger controls on a whole watershed basis, whether it's a stream or a harbor, river, or lake. And to the extent that specific chemicals causing problems can be defined, then controls can be incorporated into the regulatory process.

Now these controls may not necessarily be reductions from point sources. It may be better stormwater management or water conservation practices as a part of a municipality's permit that will prevent combined stormwater events from overflowing during times of high rainfall. It may well be that a waterbody is so polluted from contaminated sediments that there is no allowable load limit, and unless contaminated sediments or the pollutants are removed from the sediments there is no capacity left to add any more. Those are some of the creative ways that we think biological and wildlife criteria can be used in a regulatory process.

C. Those are excellent points, and to add to them, we need to monitor for feedback on the success of those applications. Many applications don't carry with them the probability that we know that constructing a sewage plant will achieve better water quality. This is an area we don't have much experience with, so we need feedback from the system to tell how things are going.

Q. *(Lee Dunbar–State of Connecticut) Like many of my scientific cohorts, we try to do things three different ways—in this case with toxicity testing, chemical analysis, and biosurveys—and hope by some streak of luck that all these ways give us the same answers so that we can look like geniuses to our peers and go happily on our way. However, I'm rather concerned about the great discrepancies between the various methods. I'm wondering if, in fact, this discrepancy is looked on as one of the criteria is wrong, or whether it just means they were measuring different things, or how this problem is dealt with?*

For example, with the chemical number in Connecticut and in much of the Northeast. We have very soft water there, and much of the ambient monitoring shows that—even in newer pristine sites—metal concentrations exceed the national guidance numbers. Now, some might interpret that result to mean that we need site-specific criteria in our region. But typically, from a regulatory standpoint, when you are dealing with a chemical number and there is an exceedance, you go directly to the permit and rachet that down. It appears that, with the biocriteria, if there is an impairment, then rather than going directly to the permit, it is more of a trigger to try to first figure out what you need to do than what the problem is. You have to identify in certain areas whether the problem is dissolved oxygen, ammonia, or if it's nutrients. And, I assume that you made that determination based on some sort of chemical or other approach. Am I correct there?

A. (Chris Yoder) Yes, in part. Some of it is knowledge of the sources and the land use, and also the type of response you got out of the biota as a signature of that type of problem. It's a combination of all that. Yes, I'm concerned that sometimes we tend to put very simple explanations on these things and not spend enough time solving them. Why that happens is extremely complex. One reason is ambient chemical sampling. That's maybe half a dozen grab samples during the summer at a site, and a laundry list of 30 parameters. What if we are missing the important dynamics of that system? It could be one of those elements, or one of those parameters, and yet we are not picking it up chemically.

Q. *How do you distinguish, based on the biocriteria, whether it's something that can be regulated through a permit process or what's causing the problem so that you can perhaps move forward? When do you go after the permittee and when do you decide it's just a habitat problem, it doesn't have anything to do with this discharge, we are going to let them alone. Or don't you attempt that?*

A. It's not entirely that direct. We are monitoring in association with major permit reissuance and doing it far enough ahead of time to plug into the process. An obvious example would be the focus of major permits in Canton, Ohio: a sewage plant at an oil refinery. This galvanizing operation had so contaminated the ground that it was just leaching zinc and iron out in the stream—and nobody knew about it. The degradation triggered off an inquiry and a further look at the chemical monitoring tipped off an investigation. We just had to assemble all the parts together.

C. Biological criteria are picking up two things that the chemical-specific criteria may not be getting. One is the combined effects of multiple pollutants; chemical criteria deal with one chemical at a time. Also, biological criteria may show that water quality is not meeting standards and chemical criteria show it is affected by other sources. We have typically used water quality standards solely to go after point sources because they are the easiest to pin down. Those sources are still important; however, water quality standards are supposed to apply to the waterbody itself and to be used in developing controls on all problem sources, whether point sources or otherwise. We have focused our efforts too long and too much on point sources; we need to figure out ways to restore the health of waterbodies. And biological criteria are telling us that we are not meeting those uses.

C. The world is a complicated place. The kinds of information that you will need to identify a source in situation "A" may be different from that needed for situation "B." You need to establish a framework for all this information to make a judgment about effects. And that's why we remain a proponent of a weight-of-the-evidence approach. Basically, it's a framework for doing a broad analysis of the situation.

Q. *(Rowland McDaniel–FTN Associates, Little Rock, Arkansas) Arkansas does have narrative biocriteria. Since 1986, the Arkansas Department of Pollution Control and Ecology has used a rapid bioassessment process that was developed for the State. This process picks 40 or 50 specific NPDES sites every year and addresses impacts on the benthic communities upstream and downstream. The results are used to tier the degrees of problematic impact on the receiving stream. If, as a result, the rapid bioassessment showed a very severe impact, the NPDES permit would be reopened. If the impact was tentative, it would be placed on a list for compliance sampling inspection coupled with a quality assurance/ quality control assessment of the laboratory. If it was a minor impact, it would be placed on an effluent sampling program where there would be point effluent sampling inspections always tied to toxicity testing. In many cases where the rapid bioassessment showed impacts, we could tie it back to toxicity testing that was not yet in the permit process. So I think biocriteria have very practical applications.*

One question for Chris. The increase in nonattainments when you went to a numerical standard was not involved in point sources so much as nonpoint sources through nutrient loadings and things like that. Is that correct?

A. (Chris Yoder) In part. That change again was an artifact of the method by which you analyze data. And the narrative was a less-disciplined, more standard approach than the latter one. Clearly, we've tested volunteer monitoring results against that and shown even a bigger discrepancy. It seems to be clearly oriented in (I hope I'm not offending any statistics people by misusing it) a Type 2 error-type situation.

Q. *(Peter Ruffier–Association of Metropolitan Sewage Agencies) I have a question for Reid Miner. You mentioned that there were some 200 different studies done with 45 dischargers. I was curious what the dischargers did with the data that were generated, whether or not there were any operational changes as a result, and if there were any impacts on the biological indicators used in the studies?*

A. (Reid Miner) A lot of these studies were performed over decades to document changes in quality, the health of the aquatic environment from the early 1970s through to the present, so to the extent that operational changes obviously took place over that time there was an opportunity to document the effect in the aquatic environment. In general terms, what the compilation of the information suggested was that within the immediate vicinity of the dischargers, there were what might broadly be characterized as enrichment effects (in terms of the nature of the biota that were present) and that, in situations where there was limited mixing available or where there were other synergistic forces or effluents involved, there were sometimes effects outside of the mixing zone. But most of the absorbable impacts were limited to the mixing zone. Most of these studies were done outside of permit conditions by companies interested in getting that interpretive framework.

Q. *(Rebecca Shriner–Indiana Wildlife Federation) The message from all of you is that we have to look at all of these systems, to view them in their complexity. What worries me is hearing some of the questions. Many people here seem to be asking which leg of Tim's three-legged stool is the best one to stand on. And Tim is trying to say that we have to use* <u>all</u> *of them. Since I have that problem with the policy, decisionmaking and political members, it disturbs me to hear it in the scientific community.*

What <u>is</u> *the one leg we are going to stand on? I'm someone who has to design and work with watersheds, and I want the couch, all six legs, and to sit comfortably because we've looked at all sorts of things. I'm worried that the scientific community is still pinpointing or focusing on what is the one best way to look at the problem. The politicians do that, but if the scientific community is doing it, it is cutting off its own nose to spite its face—and I'm very concerned about that.*

Q. *(For James Gammon) In thinking about biological criteria mostly for streams, how would you develop biological criteria in large rivers like the Wabash or some of the Alaskan rivers you've worked on? How would you set biological expectations?*

A. (James Gammon) For years, I looked for a clean river in the Midwest and didn't find one. The best section—it may not be the best available but at least it's a reasonably good comparative section—is above Lafayette. This approach has worked for the Wabash River. I didn't think it would. When I went to a meeting eight years ago, a colleague said, "That river is hopelessly polluted. Why do you bother to work on it?" And at that time, I had to agree. But in recent years, the river has amazed me. For two years, it's had a lot of bass in it.

Q. *So, you just select the stretch or the reach that's minimally impacted?*

A. (James Gammon) You have to do that for the system. What gives me hope is that we have seen significant improvement and that, to me, gives evidence that we're on the right track. That we can indeed do more because no body of water is as good as it could be. I remain optimistic that we'll identify causes that are limiting factors now, and that we will improve things still more.

AMMONIA-CHLORIDE

Toxicity of Chlorine and Ammonia to Aquatic Life: Chemistry, Water Quality Criteria, Recent Research, and Recommended Future Research

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Introduction

In 1987, more than half (53 percent) of the population in the United States lived within 50 miles of the coasts along the Great Lakes, Gulf of Mexico, and Atlantic and Pacific oceans (Lewis, 1989). While predictions vary, estimates indicate that 54 to 80 percent of this Nation's population will be residing in coastal areas by the year 2000 (Lewis, 1989; Delaney and Wiggin, 1989). As a result of this significant population growth, the amount of chlorine and ammonia entering coastal waters will undoubtedly increase.

Chlorine and ammonia are ubiquitous and highly toxic "conventional" pollutants whose sources include effluents from sewage treatment plants, large power plants, and industry (U.S. Environ. Prot. Agency, 1990a). Chlorine is used to disinfect drinking water and effluents from sewage treatment plants to protect humans from exposure to pathogens (bacteria and viruses) in drinking water, receiving waters through body contact (such as swimming, scuba diving, and wind surfing), and contaminated shellfish (U.S. Environ. Prot. Agency, 1990a). Another major source of chlorine is as a biocide in power plant cooling waters and industrial effluents (U.S. Environ. Prot. Agency, 1990a).

Biological degradation of organic matter produces ammonia in natural waters. Toxic concentrations of ammonia can be introduced into the environment through municipal sewage effluents, industrial discharges, feedlot drainage, and agricultural fertilizer applications (U.S. Environ. Protec. Agency, 1990a).

Even though this paper will describe some research findings published since the U.S. Environmental Protection Agency (EPA) published the freshwater quality criteria for chlorine and ammonia in 1985 and saltwater quality criteria for ammonia in 1989, it will not be an exhaustive review of recently completed research. Only representative studies will be discussed to illustrate some of the most significant research recently published or completed.

Chlorine

Some Commonly Used Terms

Aquatic toxicologists and regulators are often confused by the terms or definitions used to describe chlorine in water. Therefore, definitions of some terms that may aid in understanding this paper and the toxicological literature follow.

- **Free Residual Chlorine (FRC):** The portion of the chlorine injected into water that remains as molecular chlorine, hypochlorous acid, or hypochlorite ions after the solution has reached a state of chemical equilibrium (Planktonics, Inc. 1981).
- **Combined Residual Chlorine (CRC):** The portion of chlorine injected into the water that remains combined with ammonia or nitrogenous compounds after the equilibrium has been reached (Planktonics, Inc. 1981).
- **Total Residual Chlorine (TRC):** The sum of free chlorine and combined chlorine in fresh water (U.S. Environ. Prot. Agency, 1985a).
- **Chlorine-produced Oxidants (CPO):** The sum of free chlorine, combined chlorine, and combined bromine oxidative products found in saltwater (U.S. Environ. Prot. Agency, 1985a).
- **Total Residual Oxidant (TRO):** The TRO is comparable to TRC, but like CPO, it also includes the bromine compounds hypobromous acid, hypobromite ions, and bromamines found in saltwater (Planktonics, Inc. 1981).

Basic Chlorine Chemistry in Water

Fresh Water

When chlorine is added to freshwater wastewater, cooling water, or drinking water, it may react with ammonia, humic materials, and nitrogenous compounds found there to form many different types of chlorine-containing compounds (Planktonics, Inc. 1981; Christman et al. 1983; Coleman et al. 1984; Scully et al. 1988; and Thompson et al. 1990), some of which are known carcinogens such as chloroform and mutagens such as MX (3-chloro-4-[dichloromethyl]-5-hydroxy-2[5H]-furanone) (Reinhard and Goodman et al. 1982; Jolley et al. 1983; Kronberg et al. 1990; and Rav-Acha et al. 1990). Some of the most commonly formed compounds include:

- HOCL (hypochlorous acid)
- OCL^- (hypochlorite ion)
- NH_2CL (monochloramine)
- $NHCL_2$ (dichloramine)
- RNHCL, $RNCL_2$, etc. (organic chloramines)
- Trihalomethanes (THMs) (chloroform)
- Other disinfection by-products (DBPs).

The structural formulas of some of the most commonly formed THMs and DBPs are shown in Figure 1. The actual concentration of each of the chlorine-containing compounds is dependent on such physical and chemical conditions as pH, temperature, amount of initial chlorine dose, the ammonia concentration in the water, and the amount and type of organic precursors (fulvic and humic acids, proteins) found in the water (Planktonics, Inc. 1981; Coleman et al. 1984; Scully et al. 1988; Thompson et al. 1990). For example, increasing the concentration of ammonia in the water will usually increase the reaction between ammonia and HOCL to form chloramines (Planktonics, Inc. 1981).

Seawater

In chlorinated seawater, the oxidative capacity is mostly expressed through the bromine atoms found in the bromide salts that are found at concentrations as high as 60-65 ppm in 30‰ (salinity) seawater (Planktonics, Inc. 1981). As a result, chlorination of water at salinities greater than > 0.3‰ usually results in the predominant formation of bromine-containing compounds (Planktonics, Inc. 1981). These brominated compounds are analogous to the chlorinated compounds found in chlorinated fresh water (Planktonics, Inc. 1981) and form compounds similar to those produced by chlorine in fresh water (Planktonics, Inc. 1981; U.S. Environ. Prot. Agency, 1985a; Coleman et al. 1984; Thompson et al. 1990). Some of the most common bromine compounds formed in chlorinated seawater include:

- HOBr (hypobromous acid)
- OBr^- (hypobromous ion)
- NH_2Br (monobromamine)
- $NHBr_2$ (dibromamine)
- Organic bromamines
- THMs (bromoform—see Fig. 1) and
- Other DBPs.

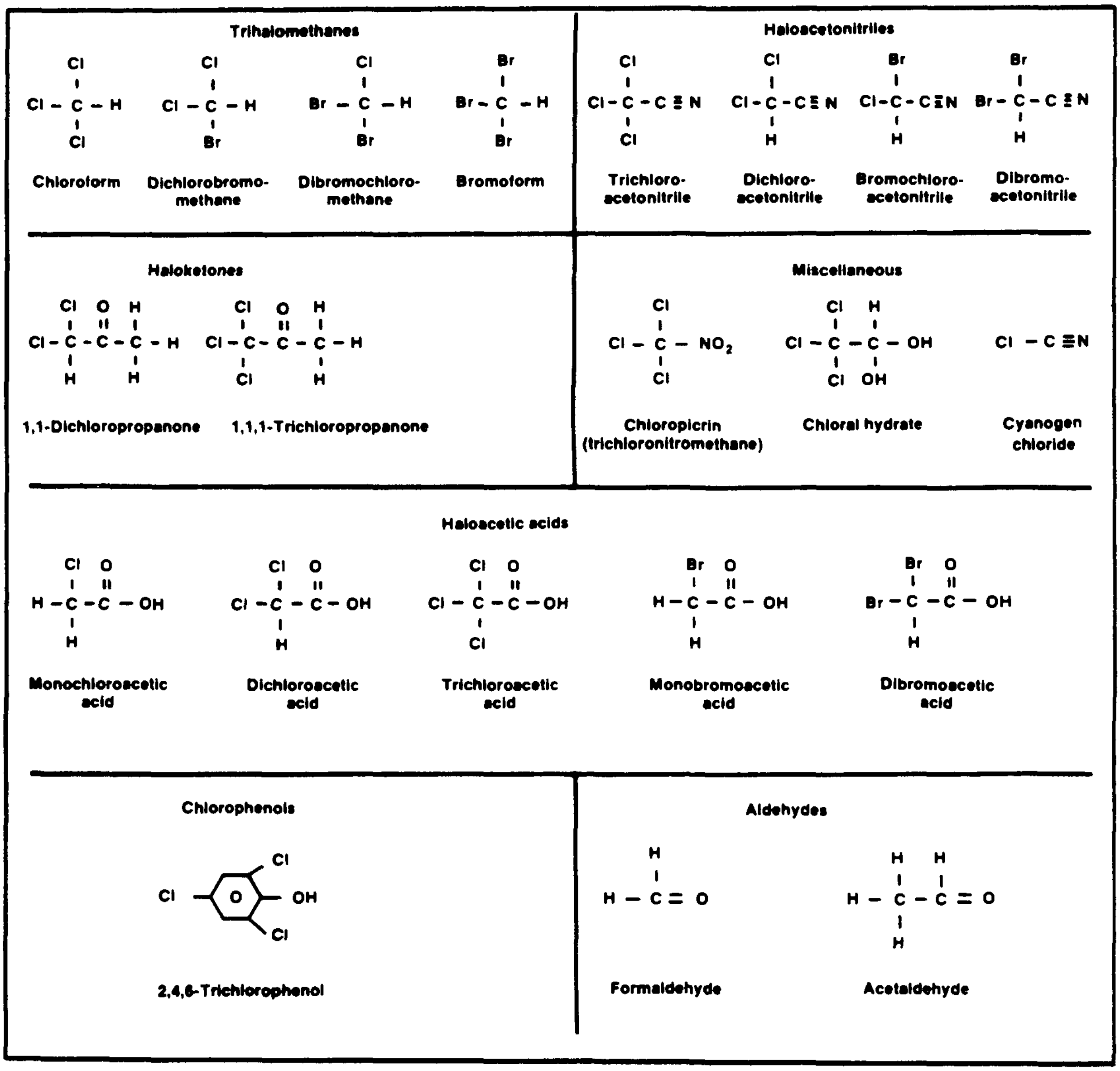

Figure 1.—Structural formulas for some trihalomethanes (THMs) and disinfection byproducts (DBPs) (Source: Krasner et al. 1989).

Chlorine Water Quality Criteria

The freshwater and saltwater chlorine criteria published by EPA (U.S. Environ. Prot. Agency, 1985a) includes acute toxicity data for 33 freshwater animals (12 invertebrates and 21 fish) and 24 saltwater animals (13 invertebrates and 11 fish). Also included are chronic toxicity data for three freshwater invertebrates and one saltwater fish.

The freshwater and saltwater criteria (U.S. Environ. Prot. Agency, 1985a) have a two-tiered structure: (1) An acute concentration (one-hour average) derived from short-term tests and effects and (2) a chronic concentration (four-day average) derived from long-term tests and effects. These criteria are summarized below:

Freshwater Criteria	Acute: 19 µg/L (0.019 mg/L) TRC (one-hour average)
	Chronic: 11 µg/L (0.011 mg/L) TRC (four-day average)
Saltwater Criteria	Acute: 13 µg/L (0.013 mg/L) CPO (one-hour average)
	Chronic: 7.5 µg/L (0.0075 mg/L) CPO (four-day average)

Note that these criteria indicate that chlorine is very toxic to aquatic life at concentrations in the low µg/L or parts per billion (ppb) range.

Toxicity of Chlorine to Aquatic Life

High levels of chlorine in water are a leading cause of fishkills in the United States (U.S. Environ. Protec. Agency, 1990a). In general, the rate of lethality from TRC is usually rapid with many mortalities in 96-hour exposures occurring within the first 12 hours (U.S. Environ. Prot. Agency, 1985a). The effects of TRC or CPO can range from avoidance behavior, growth inhibition, reproductive problems, behavioral changes, and anesthetic reactions, to death (U.S. Environ. Prot. Agency, 1985a, 1990a).

There is a wide and similar range of relative sensitivities among both freshwater and saltwater fish and invertebrates to TRC or CPO exposure (U.S. Environ. Prot. Agency, 1985a). In addition, the relative sensitivities of both fresh- and saltwater animals appear to be similar (U.S. Environ. Prot. Agency, 1985a). However, saltwater species may be more sensitive to CPO if simultaneously subjected to thermal stress (U.S. Environ. Prot. Agency, 1985a). Whereas saltwater invertebrates are more sensitive to CPO resulting from combined chlorine (chloramine) than free chlorine (sodium hypochlorite), the opposite may be true for fish (U.S. Environ. Prot. Agency, 1985a).

Numerous laboratory and field studies have also shown both TRC and CPO are acutely toxic to aquatic life at the low concentrations typically found in chlorinated wastewater effluents (U.S. Environ. Prot. Agency, 1990a). Some of these same studies have shown that toxic concentrations of chlorine persist in the effluents even after they have been discharged from the sewage treatment plant and diluted by the receiving waters (U.S. Environ. Prot. Agency, 1990a).

Petrocelli et al. (1990) conducted a study to determine the toxicity of a sewage plant's chlorinated effluent before and after it entered the estuarine receiving waters of Narragansett Bay, Rhode Island. Toxicity tests used for the effluents and receiving waters included the sea urchin (*Arbacia punctulata*) fertilization test, the red macroalga (*Champia parvula*) reproduction test, and the quahog (*Mercenaria mercenaria*) embryo/larval test.

Chlorinated effluent samples were toxic to sea urchins and quahogs, with the toxicity increasing in proportion to the amount of TRO found in the effluent. Increased effluent concentrations in the receiving water samples (estimated by a dye study) were generally increasingly toxic. Dechlorination of the effluent by using sodium sulfite was effective in reducing the chlorinated effluent's toxicity to sea urchins and quahogs but not to the red alga.

In a related study, Nacci et al. (1990) used the sea urchin fertilization test to evaluate the toxicity of chlorinated natural seawater and pre- and post-chlorinated sewage plant effluents diluted with seawater. The persistence of the TRO and toxicity was greater for chlorinated natural seawater solutions than for effluent solutions with similar initial TRO concentrations. For example, chlorinated seawater solutions with very low TRO concentrations (0.04 mg/L) were very toxic while the effluent samples with the same low concentrations were nontoxic (Nacci et al. 1990). These results suggest that the DBPs formed by the chlorination of natural seawater by chlorinated effluents may be highly toxic and more persistent than previously suspected.

Another significant finding was the discovery that the decay rates of both the toxicity and TRO concentrations in effluent samples were significantly higher in samples stored at 20°C versus 10°C. In addition, the decay rate of TRO in natural seawater samples, which was also significantly higher at 20°C than at 10°C, was dependent on the samples' initial TRO concentration (Fig. 2). This suggests that the toxicity of chlorinated effluents entering receiving waters may increase as the level of chlorination increases and remain persistent during the colder seasons (Nacci et al. 1990). More laboratory and field work must be conducted to confirm and expand this research.

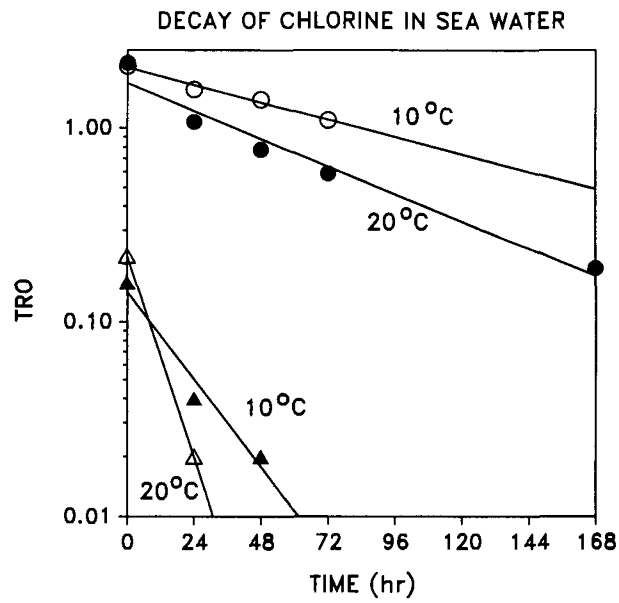

Figure 2. —Linear regressions of total residual oxidant (TRO) data versus time for samples of chlorinated seawater with initial concentrations of 2 mg/L TRO (circles), and 0.2 mg/L (triangles). Samples were held at 10°C (open circles, closed triangles) or 20°C (closed circles or open triangles) (Source: Nacci et al. 1990).

Of particular significance to aquatic food webs and human health are occurrences of brominated phenols and anisoles in freshwater and marine sediments (Watanabe et al. 1985), freshwater fish such as the fathead minnow (*Pimephales promelas*) (Keuhl et al. 1978), and Pacific oysters (*Crassostrea gigas*) (Miyazaki et al. 1981). Apparently, the production of many of the DBPs that become bioaccumulated in aquatic biota, such as brominated phenols, occurs during the chlorination of wastewater and in waters that receive chlorinated wastewater (Sweetman and Simmons, 1980; Watanabe et al. 1984, 1985).

Ammonia

Basic Ammonia Chemistry in Water

In water, un-ionized ammonia exists in equilibrium with the ammonium ion (NH_4^+) and the hydroxide ion (OH^-) (U.S. Environ. Prot. Agency, 1985b). This equilibrium can be expressed as:

$$NH_3(gas) + nH_2O(liquid) \rightleftharpoons NH_3 \cdot nH_2O(aqueous) \rightleftharpoons NH_4^+ + OH^- + (n-1)H_2O(liquid).$$

In this equilibrium, the dissolved un-ionized ammonia is represented as NH_3. The ionized form is represented by NH_4^+. The term "total ammonia" refers to the sum of NH_3 + NH_4^+ (U.S. Environ. Prot. Agency, 1985b). In addition to the concentration of total ammonia found, the pH and temperature of freshwater play a major role in determining the NH_3 concentration in the water (U.S. Environ. Prot. Agency, 1985b). For example, the concentration of NH_3 usually increases with rising pH and temperature in fresh water (U.S. Environ. Prot. Agency, 1985b).

In estuarine and marine waters, pH and temperature are the major water quality factors that control the NH_3 concentration, with both correlating positively with NH_3, and salinity, the least influential factor, inversely correlated with NH_3 (U.S. Environ. Prot. Agency, 1989). In addition, the proportion of NH_3 in fresh and marine waters is reduced about 10-fold with a reduction of only one unit within the pH range experienced by most marine animals (Miller et al. 1990). Hence, it is important that pH be tightly controlled in ammonia toxicity experiments or measured in field experiments (U.S. Environ. Prot. Agency, 1989; Miller et al. 1990).

Ammonia Water Quality Criteria

National water quality criteria for ammonia (U.S. Environ. Prot. Agency, 1985b, 1989) were developed to protect freshwater and saltwater aquatic life. The freshwater ammonia criteria included acute toxicity data for 48 freshwater animals (19 invertebrates and 29 fish) and only nine saltwater animals — six invertebrates and three fish (U.S. Environ. Prot. Agency, 1985b). This same document also included chronic toxicity data for 11 freshwater animals (two invertebrates and nine fish). No data were available for saltwater animals. Because acute and chronic toxicity data for ammonia's effect on saltwater aquatic life were limited, saltwater criteria were not derived.

By 1989, there were sufficient acute and chronic ammonia toxicity data for EPA to publish saltwater ammonia criteria (U.S. Environ. Prot. Agency, 1989). This document included acute toxicity data for 21 species of crustaceans, bivalve mollusks, and fishes, and chronic toxicity data for two saltwater animals — crustaceans (*Mysidopsis bahia*) of the family Mysidae and the inland silverside (*Menidia beryllina*)—and 10 freshwater animals.

Freshwater and saltwater quality criteria for ammonia also have a two-tiered structure: (1) An acute concentration (one-hour average) derived from short-term tests and effects, and (2) a chronic concentration (four-day average) derived from long-term tests and effects. These criteria are summarized as follows:

Freshwater Criteria	Acute and chronic criteria concentrations of un-ionized ammonia (mg/L) and total ammonia (mg/L) are provided in tables for the pH range 6.5 to 9.0 and a temperature range of 0°C to 30°C.
Saltwater Criteria	Acute: 233 µg/L (0.233 mg/L) un-ionized NH_3 (one-hour average) Chronic: 35 µg/L (0.035 mg/L) un-ionized NH3 (four-day average) Note: Tables citing criteria concentrations in terms of total ammonia (mg/L) are provided for the ranges of 7.0 to 9.0 pH, 0°C to 35°C, and for 10, 20, and 30‰.

Toxicity of Ammonia to Aquatic Life

The toxicity of aqueous ammonia to aquatic life is primarily attributable to un-ionized NH_3, with the NH_4^+ ion being relatively less toxic (U.S. Environ. Prot. Agency, 1985b). Ammonia has also been identified as one of the leading causes of fishkills in the United States (U.S. Environ. Prot. Agency, 1990a).

Ammonia affects aquatic life in two major ways. It can cause acute and chronic toxicity, and the ammonia oxidation in water can lower dissolved oxygen concentrations (Hermanutz et al. 1987; U.S. Environ. Prot. Agency, 1990a). These lowered dissolved oxygen concentrations can impair growth and delay development of fish, including increased larval fish mortality (U.S. Environ. Prot. Agency, 1990a). Concentrations of ammonia acutely toxic to fish may cause "loss of equilibrium, hyperexcitability, increased breathing, cardiac output and oxygen uptake, and, in extreme cases, convulsions, coma, and death" (U.S. Environ. Prot. Agency, 1985b). At concentrations below toxic levels, ammonia may affect fish by causing "a reduction in hatching success, reduction in growth rate and morphological development, and pathologic changes in tissues of gills, livers, and kidneys" (U.S. Environ. Prot. Agency, 1985b). Ammonia may combine with chlorine in sewage treatment plant and industrial effluents to form chloramines and other DBPs that, in turn, may be as or more toxic and persistent as ammonia or chlorine alone (U.S. Environ. Prot. Agency, 1990a).

In fresh water, the concentration and toxicity of NH_3 are largely dependent on water temperature and pH, with toxicity usually decreasing as the temperature and pH increase (U.S. Environ. Prot. Agency, 1985b, 1990a). However, recently reported labora-tory tests on nine species of freshwater invertebrates and five fish species indicated no clear relationship between NH_3 toxicity and temperature (Arthur et al. 1987). Instead, temperature, dissolved oxygen, and pH during these tests seemed to be interdependent. Other factors known to affect ammonia toxicity in freshwater environments include dissolved oxygen concentrations, previous acclimation to ammonia, fluctuating or intermittent exposures, carbon dioxide concentrations, and the presence of other toxicants (U.S. Environ. Prot. Agency, 1985b).

For salt water, little data and information exist that provide definitive evidence that temperature, salinity, or pH have a consistent influence on the toxicity of un-ionized ammonia (U.S. Environ. Prot. Agency, 1985b; Miller et al. 1990). Miller et al. (1990) investigated the influence of pH and salinity on the acute toxicity of un-ionized ammonia to two marine species, a mysid (*Mysidopsis bahia*) and larval inland silversides (*Menidia beryllina*). Also studied was the influence of temperature on ammonia toxicity to mysids and larval sheepshead minnows (*Cyprinodon variegatus*).

Miller et al. (1990) found that the acute toxicity of NH_3 to mysids and inland silversides was influenced by pH and salinity in a different and a species-specific manner. For example, at 31‰, NH3 was most toxic to mysids at pH 7.0; whereas with inland silversides, the toxicity was greatest at pH 9.0. Temperature only had a small effect on acute toxicity of NH_3 for Atlantic silversides and sheepshead minnows. The results of these experiments indicated that temperature has a much smaller effect on NH_3 toxicity with marine fish as compared to freshwater fish (Miller et al. 1990).

The results of acute 48-hour and 96-hour laboratory toxicity tests with ammonia on nine species of freshwater invertebrates and five species of freshwater fish were reported by Arthur et al. (1987). With the exception of two mollusks (the fingernail clam and snails) and one cladoceran species, all invertebrates were found to be less sensitive than fish to the short-term ammonia exposures. This finding was similar to that previously published by EPA (1985b).

The most sensitive species to NH_3 was the rainbow trout (*Oncorhynchus mykiss*) with a geometric mean LC_{50} of 0.53 mg/L. The most sensitive invertebrate was the fingernail clam (*Musculium transversum*) with a geometric mean LC_{50} of 1.10 mg/L. The ranking of fish sensitivity to NH_3 by most to least sensitive was rainbow trout > walleye (*Stizostedion vitreum*) > channel catfish (*Ictalurus punctatus*) > white sucker (*Catastomus commersoni*) > fathead minnows (*Pimephales promelas*) (Arthur et al. 1987). In general, the LC_{50} values produced in this study closely bracketed those previously reported by EPA in the 1985 water quality criteria document.

Hermanutz et al. (1987) used four outdoor experimental freshwater streams over 76 weeks to evaluate the applicability of laboratory data on ammonia effects and EPA's national and site-specific ammonia criteria. Unlike the national water quality criteria for ammonia, which are derived from a large laboratory database, the site-specific criteria were obtained by subjecting representative species (such as fathead minnows and channel catfish) to laboratory acute tests with dilution water taken from the site of the experiments (U.S. Environ. Prot. Agency, 1983; Hermanutz et al. 1987). Populations of cladocerans, copepods, rotifers, protozoans, fathead minnows, bluegills, channel catfish, white suckers, walleyes, and rainbow trout were tested in the streams for various time intervals throughout the study.

Copepods and rotifers were unaffected in all treatment streams; inclusive results were found with the cladoceran and protozoan populations. In general, the lowest effect concentrations for fish in the streams were close to previously reported laboratory chronic effect concentrations in tests up to or longer than 30 days, and all were below laboratory acute effects concentrations.

Of the six fish species tested, only channel catfish and white suckers were found to be adversely affected (a decrease in growth) at NH_3 concentrations below the national and site-specific chronic criteria. Under the exposure conditions used in this study, the site-specific criteria were between 1.3 and 2.1 times higher than the national criteria, but they were low enough to provide protection to all fish groups tested except the channel catfish and white suckers. In this case, both national and site-specific criteria appeared underprotective for these two species.

This study also showed that large fluctuations in ammonia concentrations at field sites can be expected to occur as a result of changes in the season or time of day, even when the input of total ammonia is constant. These fluctuations may be important in affecting ammonia toxicity. It has been previously demonstrated that a rainbow trout's response to fluctuating exposures of ammonia in laboratory experiments is different than its exposure to constant concentrations (Thurston et al. 1981). Because of all of these factors, great care should be taken when attempting to compare field effects concentration data with those from laboratory effects (Sullivan and Ritacco, 1985), especially when laboratory data are used to predict impacts in the field.

The effects of ammonia on survival, growth, and reproduction on the fingernail clam (*Musculium transversum*) were tested in these same outdoor experimental streams (Zischke and Arthur, 1987). Based on the number of clams recovered from streams containing low and medium NH_3 concentrations, the lowest mean concentrations affecting survival (between 0.09 and 0.16 mg/L) were higher than EPA's un-ionized ammonia water quality criteria chronic concentrations of 0.03 mg/L (coldwater species) and 0.05 mg/L (warmwater species). Therefore, the national criteria for ammonia were low enough to protect the clams in the streams. In addition to survival, growth and reproduction of the clams were adversely affected in the medium and high concentration streams with ammonia up to 1.17 mg/L.

Although invertebrates appear to be less sensitive to ammonia than fish (U.S. Environ. Prot. Agency, 1985b), Niederlehner and Cairns (1990) recently reported that ammonia concentrations below the calculated chronic water quality criterion caused significant changes in the freshwater periphytic laboratory communities tested. In particular, species richness and biomass of the protozoan community and algal biomass were significantly reduced even at the lowest tested ammonia treatment (0.01 mg NH_3/L). This low ammonia concentration was below the EPA's chronic criterion of 0.027 mg/L (temperature = 8.8°C, and pH = 8.1).

As for the potential impact of ammonia in sediments and on sediment–water column interactions, Ankley et al. (1990) recently reported that ammonia in freshwater sediment pore waters was largely responsible for the acute toxicity of the sediments to fathead minnows and the cladoceran, *Ceriodaphnia dubia*. The ammonia found in the sediments was probably produced by natural degradation of organic compounds by microbes (Ankley et al. 1990). Effler et al. (1990) also concluded from their study of Onondaga Lake (New York) that as ammonia was being released from the sediment–water interface, total ammonia concentrations in the water increased with water depth. Release of ammonia from anaerobic sediments, or resuspension of sediments by natural major disturbances, such as severe storms, or by dredging activities could release the ammonia from the sediments, which in turn could conceivably impact water-column species (Ankley et al. 1990).

Ammonia and Chlorine: Joint Toxicity

Whereas numerous laboratory and a few field studies have been devoted to determining the impact of chlorine or ammonia to aquatic species (U.S. Environ. Prot. Agency, 1985a,b; 1989), few field or laboratory studies have been conducted to determine the combined effects of chlorine and ammonia. Recently, Cairns et al (1990) examined the chronic effects of chlorine, ammonia, and chlorine plus ammonia on protozoan species richness of periphytic communities established on artificial substrates. Protozoan species richness decreased with increasing toxicant concentrations. In addition, the interaction between chlorine and ammonia was significant and the effects of the mixtures were less than additive, especially at higher concentrations.

Species richness was decreased by a "biologically significant amount" (20 percent) in 2.7 μg/L TRC, 15.4 μg/L NH_3, and a combination of 1.2 μg/L TRC and 16.8 μg/L NH_3. Significantly, all these concentrations were lower than the chronic water quality criteria for chlorine and ammonia: 11 μg/L and 35 μg/L (temperature = 19.4°C, and pH = 8.08), respectively. Hence, the existing criteria may not adequately protect these periphytic communities.

The individual and combined effects of chlorine and ammonia on freshwater stream plant litter decomposition were studied by Newman and Perry (1989). Decomposition of stream plants (*Potamogeton crispus*) by macroinvertebrate "shredders" was investigated by placing the plants in artificial

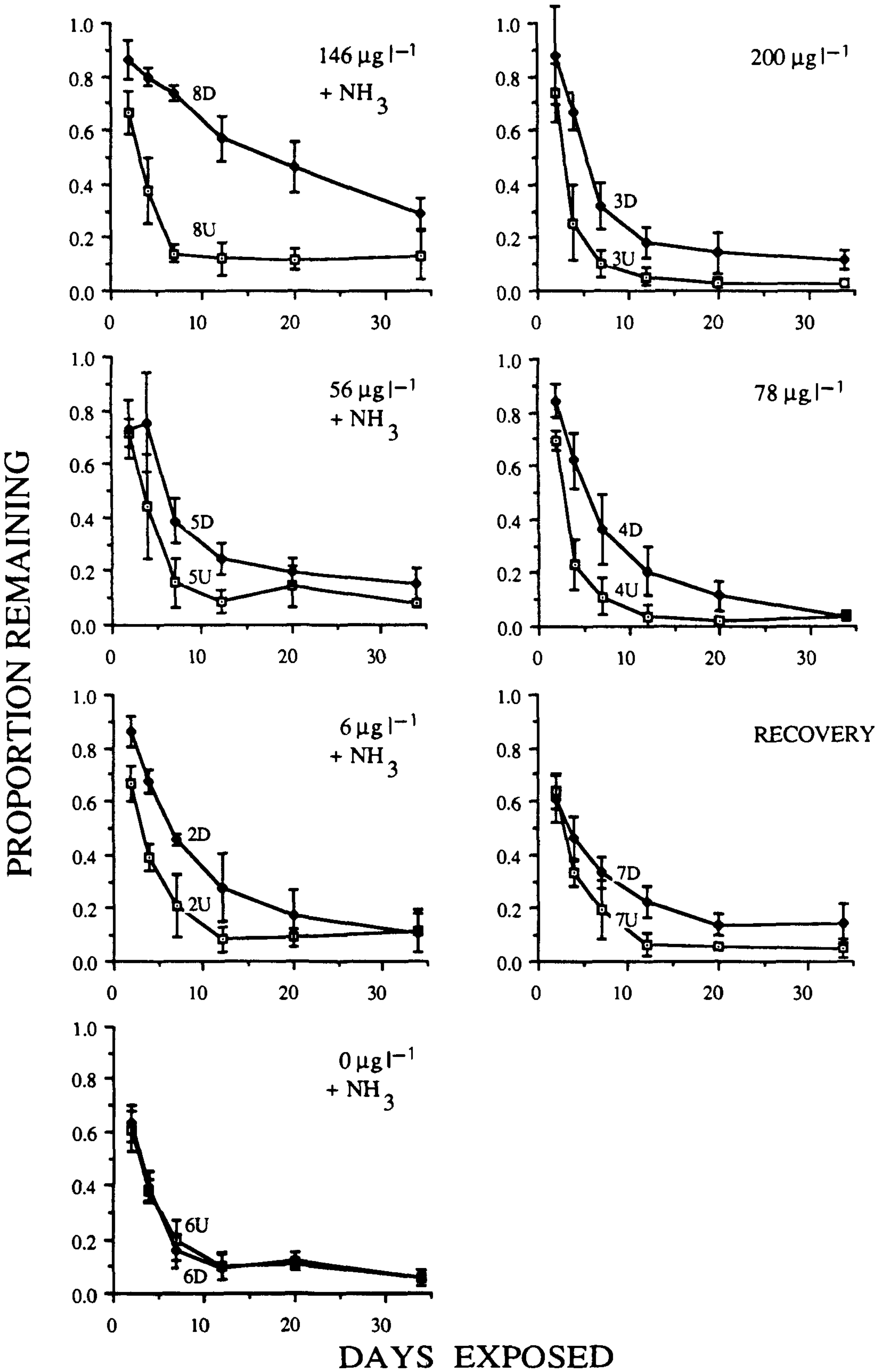

Figure 3. —Decomposition (proportion of initial litter remaining) of *Potamogeton crispus* in seven streams during June and July 1986. Upstream (U: no dose) sites are indicated by open squares and downstream (D: dosed) sites are indicated by closed diamonds. Stream numbers and sites are shown beside each line and chlorine doses [TRC (µg/L)] are given for each stream. Ammonia addition is indicated by + NH_3. Vertical lines represent ± 2SEs (Source: Newman and Perry, 1989).

streams containing different concentrations of chlorine and chlorine plus ammonia. In general, there was less decomposition in downstream sites dosed with high chlorine alone and high chlorine plus ammonia than in upstream reference sites (top of Fig. 3).

Even though this study showed that chlorine in wastewaters may have a greater impact on aquatic life than ammonia, there was a strong indication that chlorine plus ammonia combinations were more toxic than chlorine alone (Newman and Perry, 1989; Hermanutz et al. 1990). Hence, at least in some cases, removal of ammonia from chlorinated effluents may reduce effluent toxicity (Newman and Perry, 1989).

Hermanutz et al. (1990) used the outdoor streams at EPA's Monticello Ecological Research Station (Minnesota) to determine the relative sensitivity of four fish species — bluegill, channel catfish, white sucker, and rainbow trout — to chlorine alone and chlorine plus ammonia. Unlike previously published laboratory results, the effects of chlorine alone were not as dramatic. When chlorine alone was added, no consistent relationship between TRC concentrations and growth and survival of bluegills, white suckers, and rainbow trout was observed. However, there was a consistent pattern of reduced growth in channel catfish exposed to increasing TRC concentrations.

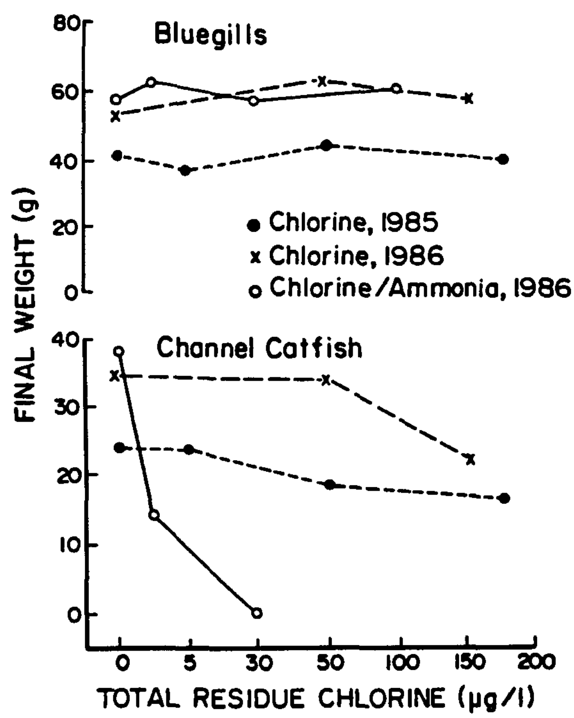

Figure 4. —Total residual chlorine (TRC) effects on freshwater fish growth (Source: Hermanutz et al. 1990).

Even though the bluegills were unaffected when approximately 3 mg/L ammonia was added to the chlorine-treated streams, all channel catfish died when exposed to 0.024 mg/L TRC, a concentration well below the mean acute value of 0.090 mg/L for this species (Hermanutz et al. 1990). In addition, growth was reduced at < 0.001 mg/L (1 µg/L) (Fig. 4). Thus, survival and growth of channel catfish were reduced in ammonia- and chlorine-treated streams that had TRC concentrations below both the laboratory acute values and the chlorine criteria chronic value of 0.011 mg/L TRC (U.S. Environ. Prot. Agency, 1985a).

Hermanutz et al. (1990) also found that the concentration of TRC was influenced when ammonia was added to the streams. When only chlorine was added, a regular diel pattern occurred with reductions of TRC during the day from sunlight photodegradation (Fig. 5). When ammonia was added, the TRC concentrations did not fluctuate daily, thus indicating that factors other than sunlight may influence TRC degradation, at least in the high-concentration chlorine and ammonia streams (Fig. 5) (Hermanutz et al. 1990).

Because ammonia may dramatically alter or enhance the toxicity of chlorine found in wastewaters, much more research similar to that conducted by Cairns et al. (1990), Newman and Perry (1989), and Hermanutz et al. (1990) is needed on both freshwater and saltwater species to verify or improve upon the existing water quality criteria for chlorine and ammonia.

Future Research Needs

To protect freshwater, estuarine, and saltwater aquatic life are protected from the potentially adverse impacts of chlorine or ammonia or the chemical by-products (THMs and DBPs) formed by chlorine–ammonia interactions, the following research topics should be supported and investigated.

Chlorine Studies

- Because recent research has shown that laboratory data do not always agree with field-collected data, more in-stream and fresh- and saltwater receiving water studies are needed (U.S. Environ. Prot. Agency, 1990b; Hermanutz et al. 1990; Hedtke, 1990).
- Much more research needs to be conducted on the formation and fate of chlorination by-products, including known or suspected mutagens and

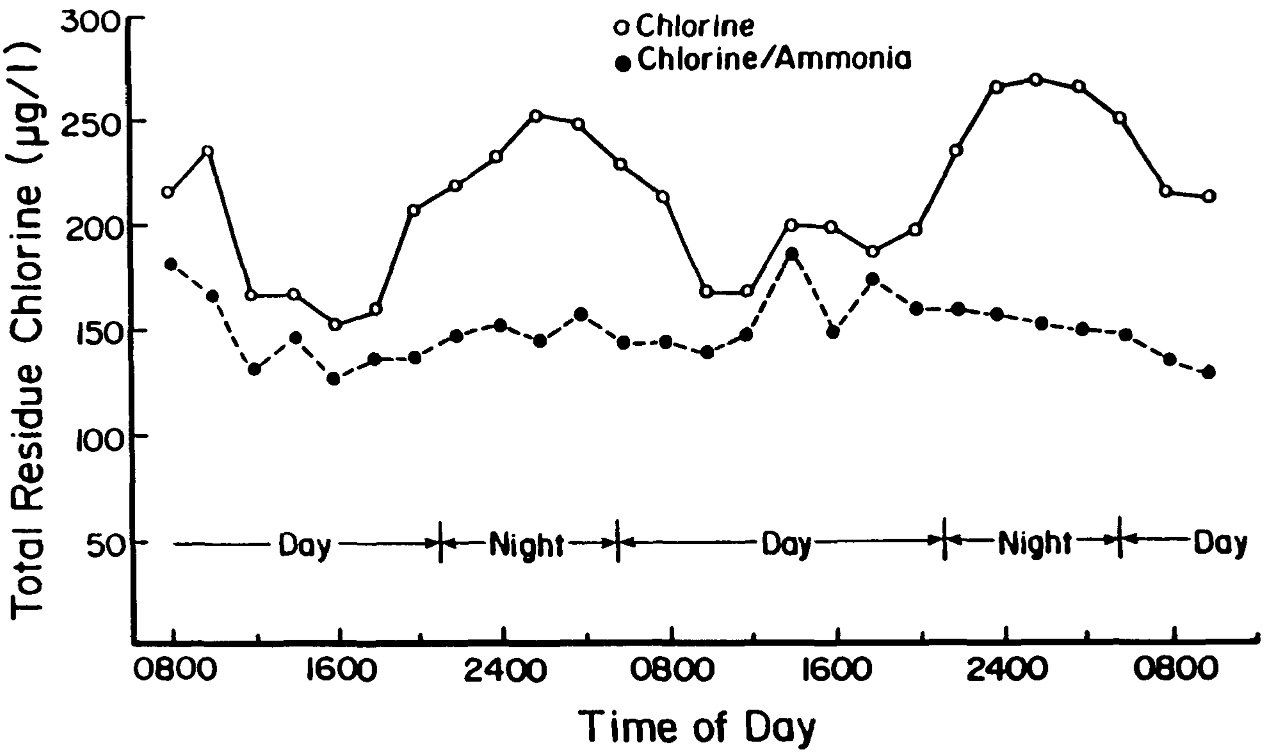

Figure 5. —Diel total residual chlorine (TRC) concentration (µg/L) at Station 2 in the high-chlorine and high chlorine/ammonia treatment streams from July 17-19, 1986 (Source: Hermantuz et al. 1990).

carcinogens (U.S. Environ. Prot. Agency, 1990b; Helz, 1990; Macler, 1990; Middaugh, 1990).

- Additional research is needed to determine the acute and chronic toxicity, including bioaccumulation potential, of chlorination by-products (chloramines and broma-mines) on both freshwater and marine aquatic life (U.S. Environ. Prot. Agency, 1985a, 1990b; Fayad and Iqbal, 1987). In addition, more chlorine-ammonia interaction studies are needed, similar to those previously discussed in this paper (Newman and Perry, 1989; Cairns et al. 1990; Erickson, 1990; Hansen, 1990; Hermanutz et al. 1990).

- Because other processes besides chlorination, such as ozonation and ultraviolet light, are now being used more frequently to disinfect wastewaters, more research should be conducted to measure and characterize the chemical by-products formed from these alternative processes (U.S. Environ. Prot. Agency, 1990b).

Ammonia Studies

- Much more research should be conducted to determine the effects of fluctuating and intermittent exposures to ammonia on a large variety of both freshwater and saltwater species (U.S. Environ. Prot. Agency, 1985b, 1989; Hermanutz et al. 1990). This research would also include a determination of the effects of water quality changes resulting from tidal and diel changes in salinity, pH, and temperature on the toxicity of ammonia to estuarine and marine aquatic life (U.S. Environ. Prot. Agency, 1989).

- Additional research is needed to further assess the effects of pH and temperature on the toxicity of ammonia to aquatic life (U.S. Environ. Prot. Agency, 1985b, 1989). This could include the development and evaluation of different chronic endpoints at low temperatures for freshwater species (Erickson, 1990; Hansen, 1990) and determination of the influence of temperature with freshwater and saltwater species that tolerate extreme temperature ranges (U.S.

Environ. Prot. Agency, 1989; Miller, 1990).

- Besides pH and temperature, more research should be conducted on other water quality parameters, such as salinity, oxygen concentration, chlorine concentration, and alkalinity, that may influence the toxicity of ammonia to aquatic life (U.S. Environ. Prot. Agency, 1985b, 1989; Miller et al. 1990).

- Because of the potential toxicity to biota that live in and above sediments containing high concentrations of ammonia, more research is needed to determine the relative contribution of ammonia to the toxicity of freshwater and marine sediments (Ankley, 1990). This research should also determine the potential of water-column impacts from resuspended sediments and the influence of receiving water and sediment chemistry on the toxicity of ammonia (Ankley, 1990; Erickson, 1990).

- Basic research should be conducted to determine the relative contribution of NH_4^+ to toxicity, and the physiological mechanisms of ammonia exchange and metabolism by aquatic organisms (U.S. Environ. Prot. Agency, 1989; Erickson, 1990).

Conclusion

To date, the water quality criteria for chlorine and ammonia have apparently been effective in protecting aquatic life. However, recent research has shown that much is still to be learned about the chemistry and toxicity of chlorine, ammonia, and the by-products of chlorine and ammonia interactions.

Since societal needs for clean water and ecological concerns must both be considered when making decisions about disinfection and removal of nutrients, such as ammonia from wastewaters, the research topics previously described must be initiated and completed to verify and improve upon the existing water quality criteria for chlorine and ammonia. By doing this, we will make the best and most economical decisions to protect both human and environmental health.

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Should Ammonia and Chlorine Be Regulated as Toxic Pollutants? A POTW Perspective

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Introduction

Should chlorine and ammonia be regulated as toxic pollutants? If this question were to be posed to a chemist or toxicologist not familiar with environmental regulations and U.S. Environmental Protection Agency (EPA) activities, the response might well be "Is this a trick question?" The answer to both questions could be, "Maybe, maybe not."

After all, chlorine and ammonia are chemicals with commonly known toxic properties. The laboratory and industrial hazards associated with them are essentially conventional wisdom in these settings, and it must seem intuitive that they represent a potentially large source of toxicity in wastewater discharges. Indeed, even a cursory review of the literature reveals ample evidence that residual chlorine and ammonia in wastewater discharges have caused fishkills and impacted fisheries. Hence, the suspicion that the question about regulating them is a trick. In all fairness, this question should be viewed in light of some EPA guidelines for classifying a chemical as a toxic pollutant as well as ways to assess and control the toxicity of these two chemicals when they are problems.

EPA has described the guidelines for assessing additions and deletions to the toxic or priority pollutant list (U.S. Environ. Prot. Agency, 1979). There are 10 factors that distill down to two issues: the toxicant's effects and potency, and the estimate of exposure potential to humans and wildlife. With regard to the nature and extent of toxicity to affected aquatic organisms, EPA (1979) has also indicated that the organisms' expected distribution and importance may be taken into account when classifying the pollutant.

The germane effects of chlorine and ammonia are limited to acute and chronic toxicity to aquatic organisms, with potencies ranging over approximately three orders of magnitude for each, depending upon organism sensitivity. There is no evidence of genetic toxicity effects. The potential for human exposure to ammonia and chlorine from food or water contamination by publicly owned treatment works (POTWs) discharges is nil. The exposure potential to wildlife is normally limited to aquatic organisms in the vicinity of the discharge point, although in some cases effects may be apparent at some distance from the discharge point. Neither chemical has a propensity to bioaccumulate, nor has synergistic toxicity been apparent for either. The significance of the exposure to either ammonia or chlorine will be site-specific and will depend on such factors as:

- Whether the receiving water is a lake, river, estuary, ocean, or ephemeral stream;
- Physical parameters such as temperature, pH, ionic strength, mixing and dilution,

dissolved oxygen, tidal changes, and marine upwelling;

- Presence of other discharges in the effect zone; and
- Natural presence or absence of sensitive organisms.

Although ammonia and chlorine have a potential for toxic impact because they are toxic to some species at very low concentrations and they are present in a geographically dispersed array of point source discharges (exemplified by POTWs), they may be relatively limited in the areal extent of biologically significant impact in a great many cases. Because both lack the array of physical–chemical and toxicity properties of the existing priority pollutants, they should not be included in that category. Although EPA has developed water quality criteria for both ammonia and chlorine, establishing numerical limits for all discharges using existing EPA methodology may not adequately protect some ecological settings and will probably overprotect many others. The ecological costs for the former are difficult to define, but for the latter case of overprotection, the dollar costs to the taxpayer are staggering.

Instead of a simplistic over/under numeric limit regulatory approach, this paper proposes a strategy containing case-by-case guidelines that would include water quality testing, toxicity testing, and ecological evaluations to determine the effects of chlorine or ammonia in a specific receiving water. Once an evaluation is completed, if actions are appropriate to remediate a toxic impact in a receiving water, it should be evident which course should be taken. The ecological evaluation can act as a baseline for assessing effectiveness of the control strategy and should be especially useful when the magnitude of the impact was uncertain or controversial at the outset. Where a discharger elects not to conduct the toxicity assessment or when the assessment reveals a significant problem, information contained in the water quality criteria can serve as a basis for setting numeric criteria.

Toxicity and Exposure Factors

Guidelines presented by EPA (1979) for considering a chemical as a toxic pollutant are included in the following paragraphs with a summary of pertinent information for chlorine and ammonia. We do not know whether these guidelines are still relevant to EPA rulemaking, but they formed the basis for the Agency's decision not to include ammonia as a priority pollutant in 1980.

■ **Toxicity.** The relevant literature on ammonia toxicity has been reviewed thoroughly by EPA (1985). Ammonia has no known genotoxic effects; that is, it does not cause carcinogenic or mutagenic damage. However, above safe threshold concentrations, ammonia does exhibit acute and chronic toxicity to different organisms over a wide range of concentrations. The most toxic form of ammonia is the un-ionized molecule, NH_3; the ratio of NH_3 to the ionized form (NH_4^+) increases as pH increases, so that at any given total ammonia ($NH_3 + NH_4^+$) level, aquatic toxicity increases as pH increases.

Toxicity also increases as temperature decreases, but declines in saline waters. Some species, particularly the salmonid fishes, are exquisitely sensitive to NH_3. Most aquatic plants, on the other extreme, are not very sensitive to ammonia toxicity but rather use ammonia nitrogen as a nutrient. Fish do not seem to have the ability to detect or avoid toxic levels of ammonia in a water column, and the acute effects of ammonia can be manifested quickly as a result of the common point of impact—the gills. Chronic effects in both vertebrates and invertebrates can include lowered reproductive efficiency and growth rate and a number of central nervous system disturbances caused by impaired respiration and related problems. Some of these chronic effects seem to be reversible once exposure has ceased, although for some species and effects, this is not the case.

Chlorine residuals do not cause any known genotoxic effects in plants or animals. Residual chlorine may exist as hypochlorite or as chloramines, and each of these forms causes varying degrees of acute and chronic toxicity in aquatic organisms. Fish can detect and avoid toxic levels of in-stream chlorine (Grieve et al. 1978), and at least some invertebrates can lower their respiration rates to minimize the effects of chlorine (Khalanski and Bordet, 1980; Blogoslawski, 1980; Laird and Roberts, 1980).

Acute effects of chlorine in fish also appear to focus at the gills, where the effects can manifest themselves quickly. Chronic effects can include impaired respiration and reproductive efficiency. The effects of intermittent chlorine exposure may vary on a site-specific basis, depending upon species sensitivity and mobility.

Chlorine disinfection is known to produce trace levels of halogenated organic compounds, some of which have their own toxic properties. These are addressed separately in drinking water regulations and water quality criteria. In POTW effluents, the production of chlorinated organics during disinfection is decreased by the presence of ammonia (Baird et al. 1979b), as the reaction to form chloramines proceeds at a greater rate than reaction to produce specific chlorinated organics, such as the trihalo-methanes.

- **Aquatic Environment Persistence, Mobility, and Degradation.** Chlorine residual and ammonia species are readily soluble in water; hence, they migrate readily within the water column. Neither are normally persistent chemicals in receiving waters, although under some site-specific conditions, either may be a problem. Ammonia's persistence and degradation are primarily a function of removal through the nitrogen cycle: nitrifying bacteria readily oxidize ammonia to nitrate ion, which is a plant nutrient. Chlorine residual species are oxidants (the chloramines only weakly so) and readily dissipate as a result of simple redox chemistry in aquatic systems. Sunlight, temperature, and the presence of reducing chemical species are important functions in reaction rate.

- **Bioconcentration.** Neither ammonia nor chlorine has a propensity to accumulate in animal or plant tissues.

- **Octanol: Water Partition Coefficients.** This is an experimentally derived value that is used as a surrogate measure of bioconcentration factor or ability to concentrate in fatty tissues. It is usually applied to hydrocarbon molecules when actual bioconcentration factors have not been determined. Octanol:water partition coefficients are meaningless for ammonia and chlorine.

- **Synergistic Potential.** Synergism (greater than additive toxic effects from the action of two or more toxicants) is not readily demonstrated for either chlorine or ammonia. Ammonia toxicity is controlled by pH, salinity, and temperature, but these are chemical equilibrium factors rather than synergism. Low dissolved oxygen stress increases fish sensitivity to ammonia, but since it is not the combined effects of two toxicants, it is not truly considered synergism.

- **Extent of Point Source Pollution.** Ammonia is a natural bacterial by-product of domestic wastewater treatment processes. Only a small percentage of the more than 15,000 POTWs use specific ammonia removal processes, such as nitrification; hence, POTWs represent wide-spread point sources of ammonia in receiving waters. A number of industries may contribute significantly higher concentrations in some places.

  Chlorine is required for disinfection in the majority of wastewater treatment (and drinking water treatment) facilities in the United States. Chlorine is also used as a biocide in cooling water, particularly in power generating plants in coastal locations that use single pass seawater cooling. Effects should be limited to a definable zone in the ambient receiving water near to the discharge point in many cases. There is no propensity for chlorine dispersal in plants, animals, or ambient sediments.

- **Potential for Human or Wildlife Exposure.** There is little or no potential for human ingestion of ammonia or chlorine through food or drinking water contaminated by wastewater or cooling water discharges because both chemicals disappear rapidly in a receiving water and do not accumulate in the food chain. As a matter of perspective in regard to human exposure, chlorine remains the preferred drinking water disinfectant; a large percentage of the U.S. population consumes drinking water with a chlorine residual.

  Aquatic organisms near POTW discharges will probably be exposed to both chlorine and ammonia. Although fish avoid residual chlorine in ambient waters (Grieve et al. 1978), they appear not to have this same instinct or ability for ammonia (U.S. Environ. Prot. Agency, 1985). Obviously, immobile and sessile organisms cannot avoid either chemical. Whether or not avoidance should be considered a toxic impact on receiving waters because of habitat loss is debatable, but this loss should be considered as a potential issue.

- **Production Volumes.** U.S. production volumes are high for both chlorine (23 billion pounds) and ammonia (34 billion pounds) (Am. Chem. Soc. 1989). However, the aquatic pollution potential is probably related more to water and wastewater treatment processes than to manufacturing by-products. In this context, the resulting ambient concentrations typical of POTW and receiving water scenarios are more relevant than the total mass of either chemical.

- **Use Patterns.** In cases where industries use chlorine or ammonia in a process that results in a sewer discharge, neither is likely to contribute directly to receiving water toxicity. Chlorine will be reduced very rapidly in the sewer. Ammonium salts reaching the facility are an energy source for various organisms in the treatment process. The ammonium ion is a natural component of domestic waste degradation and the main source of ammonia in POTW effluents. Chlorine's use as a water and wastewater disinfectant or cooling water biocide probably represents the most widespread source of chlorine in aquatic environments. For example, two-thirds of the POTWs in the United States use chlorine for disinfection.

- **Analytical Capabilities.** Although classical and modern analytical methods can detect total ammonia concentrations down to about 10 µg/L, there is no method capable of determining un-ionized ammonia at trace levels in aquatic samples. The estimated amount of NH_3 must be calculated by using total ammonia, pH, temperature, and ionic strength data.

  Chlorine residual species in aqueous samples can be differentiated between free chlorine (hypochlorite) and individual chloramines by using *Standard Methods for Examination of Water and Wastewater* (1989). However, for low levels of chlorine, the methodology is limited to about a 10 µg/L detection limit, and cannot differentiate between free and combined species at this level. The method is not capable of detecting residual chlorine encompassing all EPA water quality criteria (U.S. Environ. Prot. Agency, 1984).

- **Significance.** The concept of the significance of a pollutant's impact is a pivotal issue in any decision to regulate. EPA's 1979 guidelines allude to "significance of the impact and significance of the organism impacted." Is this a biologically significant impact? Is the wording meant to connote the ecological importance or the economic importance of the affected organism?

The concepts of designated use or beneficial use of a receiving water must also be important in this context of regulatory decisions. Therefore, one can find terms and definitions in various rules, regulations, and guidelines to the extent that they are convenient for determining limits, compliance, and enforcement. However, neither in this paper nor in referenced regulations will biological significance be defined. It is the purpose of the intended discussion to use the term conceptually rather than to define it.

Clearly, experience and the literature demonstrate that biological effects of various pollutants can be detected at some level in a great many settings. The challenge is to determine when a scenario requires achievement of a no-effect threshold and when an estimated or measurable effect can be tolerated without incurring significant detriment to the ecologic balance. For chlorine and ammonia, because they can exert sub-lethal effects on sensitive aquatic organisms at very low concentrations and both are present in widespread sources, the potential exists for a widespread toxic impact. It has apparently been this potential coupled with the actual documented receiving water problems that continue to drive the attempts to include chlorine and ammonia on the list of toxic pollutants and apply numeric criteria for their control.

An EPA staff report (1990a) has cited reports estimating that thousands of POTWs are causing effects in receiving waters because of chlorine and ammonia, based upon actual biological measurements or on comparison of chemical data to EPA water quality criteria. However, especially in the cases where the estimations rely upon comparison of chemical measurements with calculated criteria, the accuracy of the assumption or the in-stream significance of the assumed effects cannot be evaluated.

Ammonia and Chlorine Removal in POTWs

Chlorine

For discharges where chlorine residual does not pose a significant problem to indigenous aquatic life, it is common practice to let the residual dissipate passively. Not only is this cost effective, but the increased chlorine contact time provides an additional margin of disinfection safety. This concern for public health protection is of particular importance in effluent-dominated streams that the public may use for recreation. However, it is this practice combined with occasional spills that contribute to the documented cases of fishkills and other in-stream damage. If residuals must be removed before discharge in cases where body-contact use occurs, the chlorine dose has to be increased before dechlorination to achieve the margin of disinfection safety previously produced by passive methods.

For situations requiring active dechlorination, sulfur dioxide is the most cost-effective reductant. The technology is relatively straightforward, as are costs. Large treatment plants can install bulk storage facilities and dosing equipment; costs range between \$0.5–\$1 million, depending upon size. Smaller facilities may elect to use small cylinders of SO_2, which keeps capital expenditures low. Operational expenses may be somewhat higher for small cylinders because of additional labor and higher per unit SO_2 costs.

Facilities using bulk storage currently incur costs averaging approximately \$13 per 10 million gallons per day (MGD) treated, per 1 mg/L chlorine residual removed. This translates to an annual cost of nearly \$5,000/10MGD/mg/L residual. In southern California, for treatment of about 1.0 billion gallons per day (BGD) of flow having typical end of process chlorine residuals in the 3 to 5 mg/L range, annual dechlorination costs could range as high as \$2 million if dechlorination were required to meet fixed limit discharge requirements.

Some variables in this estimate would decrease the figure, including point of application of the limit (end-of-process, end-of-pipe, or mixing zone), delivery costs in certain geographical areas, and the amount of safety equipment required by local regulations. These appear to be moderate costs where residual chlorine is causing significant in-stream problems.

Ammonia

Removal of ammonia is a considerably less straightforward proposition, both operationally and economically. Conventional activated sludge secondary treatment yields effluents containing approximately 15 to 30 mg/L total ammonia. Variations such as pure oxygen-fed systems may range higher, in the 40 to 50 mg/L range. Only the biological nitrification process is considered. Physical-chemical methods such as air-stripping are not considered here because of air emission considerations. Some activated sludge systems may be operated with a degree of nitrification that will yield less ammonia than the indicated 15 to 30 mg/L range. However, reliable ammonia removal typically requires dedicated operation of the nitrification process, which translates to complete ammonia removal.

Ammonia removal in these cases can be considered as two phases for cost estimates: nitrification and denitrification. Nitrification, a biological oxidation of ammonia to nitrate ion, requires additional air in the process. Denitrification, the biological conversion of nitrate to nitrogen gas, requires at a minimum, extra tankage in the plant. Denitrification is a necessary part of the process, both operationally to condition the activated sludge for reliable nitrification and environmentally to limit the discharge of toxic concentrations of nitrite and nitrate ions. Because of its toxic effect in humans, the nitrate ion is a particular problem where a discharge stream either enters an aquifer or is upstream of a potable water treatment system. In semi-arid regions where groundwater basins are being recharged with treated wastewaters either intentionally or incidentally, there may be a serious need for denitrification of nitrified effluents.

The capital costs for extra tankage for denitrification are approximately \$800,000/10 MGD. The nitrification step requires an increase of approximately 70 percent in air uptake. The actual increase in amount of air supplied to the activated sludge can be less than this, depending on such factors as the condition of the sludge and waste stream and the type of air diffusers. The County Sanitation Districts' engineering staff has estimated that the use of the more efficient, fine bubble diffusers will require less than a 50 percent increase in supplied air; the increased annual energy costs for aeration would amount to approximately \$80,000/10 MGD.

In the Los Angeles basin, initial capital costs are estimated to be between \$80 to \$85 million, depending on whether or not aeration systems needed to be converted to the more efficient mass transfer equipment. The regional energy costs (for fine bubble systems) for the added air needed for nitrification would then be approximately \$24.5 million a year.

Biomonitoring as a Location-Specific Method of Toxicity Evaluation

EPA and many States have been pushing the concept of biomonitoring using acute and chronic bioassay methods to detect and prevent the "discharge of toxic materials in toxic amounts" (U.S. Environ.

Prot. Agency, 1990b). In this context, the bioassays have been proposed as a means of augmenting the conventional approach to toxicant regulation that uses target chemical analyses and numeric limits. The bioassays' purpose is to detect toxicity that might not otherwise be predicted from target chemical analysis alone.

The limitations of the chemical-specific approach are twofold. First, standard EPA analytical methods must be used for the priority pollutants: the active toxicant has to be on the list and also has to be detectable. Since most effluents contain a complex molecular mixture consisting of a multitude of chemical species not on the list, the chances of a predetermined list comprising all or even the most important toxicants is remote.

Secondly, the list has a derived set of criteria that is represented as being protective of a given environmental compartment (human health, freshwater organisms, and so forth). These criteria are not empirical numbers but rather estimates based upon biological models and sets of assumptions. The degree of uncertainty in each estimate varies and usually is not expressed; nonetheless, the criteria form the main basis for a numeric regulatory limit.

A proposal to add ammonia and chlorine to the list suffers from these same problems and does not necessarily efficiently protect a receiving water. The toxic forms of ammonia and chlorine are not directly measurable at all applicable levels in the derived criteria. The concentrations have to be estimated from the best chemical methods available and from other water quality measurements. The uncertainty in this and in the derived criteria, as exemplified for ammonia by Lewis (1988), is probably large; NH_3 concentration is a function of temperature, ionic strength, pH, and total ammonia concentration, and the potency of NH_3 varies widely among aquatic species. Because the criteria are derived from laboratory tests and designed to protect the most sensitive of the species in these tests, the uncertainty will be complicated by lack of correlation between the model test species used to develop the criteria and native species sensitivity.

Furthermore, the point of in-stream impact and the effects of intermittent exposure above the numeric criteria cannot be accurately known. As a result, whether or not the criteria will yield appropriately protective regulatory limits is *a priori* unknown for any discharge site. Certainly, one could extrapolate a judgment on this issue from those cases where adverse impacts have been measured, but the assertion here is that there is a better approach.

The Hazard Assessment Method

When whole effluent biomonitoring is used either as an adjunct or alternative to chemical-specific standard setting, use of selected bioassay protocols with "model" organisms is typically required; toxicity data thus generated are applied to a fixed toxicity limit for regulation. This is only one narrow use of biological tests. The process proposed herein is often termed "hazard assessment," and the American Society for Testing and Materials has sponsored several symposia on the subject. These assessments provide much more useful information relevant to a given site than can be obtained from simple effluent bioassays. This is accomplished by increasing the array of model organisms and combining lab assays with in-stream assays, chemical testing, and biomass profiles in a specific location. While these may not be cheap or quick tools for mapping toxicity, the costs and increased predictive accuracy are easily warranted by the potential costs of an across-the-board removal policy for chlorine and ammonia. (The issue here is not whether a community can afford to add the treatment, but rather whether the costs should be incurred if no significant benefits will accrue.)

Ammonia and chlorine, unlike the existing list of priority pollutants, are not genotoxic, bioaccumulative, or expensive to analyze. They lend themselves to a more unique and meaningful evaluation in a given environmental setting, using combined chemical and biological methods. Ammonia and chlorine can be measured easily in both effluents and ambient waters, and the toxic form of either may be removed from a sample by simple chemical means. This affords a way of determining how either may contribute to the acute or chronic toxicity detected in an effluent and receiving water, and whether either is significantly affecting the receiving water. Biomass or ecological studies are also recommended here to more rigorously define "significant."

Laboratory Assays with Chemical Control

Laboratory bioassays should be used for a number of purposes in a location-specific toxicity assessment. Standard protocols for measuring both acute and chronic effects in fresh or marine waters are available (Peltier, 1978; Weber et al. 1988; Horning et al. 1989; Standard Methods, 1989). Short-term acute tests with either juvenile or adult organisms provide a relatively inexpensive screening method to measure toxicity levels in effluents and receiving waters. Life-cycle or sensitive life-stage chronic assays provide a means of estimating effects on end points such as reproduction and growth.

Again, standard test organisms or local significant species can be used. Specific toxicity of chlorine or ammonia to the selected test species can be obtained from the literature or determined empirically under control conditions. Effluent and ambient water tests for relevant chemical and physical parameters must accompany the bioassays.

Acute fish bioassays and ammonia toxicity provide a good model for chemical control experiments. Ammonia toxicity frequently complicates interpretation of toxicity tests of effluents because of the typical rise in pH that accompanies aeration during the test (Baird et al. 1979a). The pH rise causes an increase in the more toxic NH_3 concentration. For example, a pH rise from 7.2 to 8.4 results in a 15-fold increase in the un-ionized ammonia and a predictable increase in fish mortality in the test.

The contribution of ammonia to fish mortality during the course of testing POTW effluents in static acute tests can be estimated from data for total ammonia, pH, temperature, salinity, and the specific potency to the test species. Control of pH during the test can be accomplished either by periodic addition of a buffer or continuously through addition of CO_2 (Baird et al. 1979a). This technique also allows assessment of the contribution of ammonia to the observed sample toxicity by comparing bioassay results at selected pH (that is, NH_3) levels.

Effluent testing alone is not sufficient to predict receiving water ammonia toxicity in most instances because this approach must rely upon simple mixing ratios to extrapolate to receiving water toxicity. Ammonia concentration will be reduced by processes besides simple mixing. Therefore, ambient receiving water must be included in a specific site evaluation. The pH control bioassay techniques are directly applicable to estimating the toxic effects of ammonia in the ambient receiving water. Chemical testing for ammonia will help define a mixing zone or plume and identify zones of potential ammonia toxicity. With little or no modification to standard acute bioassay protocols, ambient waters may be tested with the same organisms used for effluent toxicity tests.

Exceptions to this exist for estuarine and marine receiving waters, where species selected for ambient water bioassays will usually differ from species used for effluent monitoring. In these cases, the opportunity exists to use test organisms of significance in the local receiving water. Ammonia control experiments in ambient water testing should consist of pH control at neutral pH and ambient pH. Continuous CO_2 addition with feedback control of pH is preferable to daily pH adjustment with acid in cases where the ambient water's natural buffering capacity is insufficient to maintain the adjusted pH throughout the course of the assay. Otherwise, test organisms are subjected to a cyclic rise and fall of pH and NH_3 during the test, and results will be difficult to interpret.

The ability to compare effluent and ambient water toxicities and the opportunity to select locally significant test organisms are extremely valuable to the toxicity assessment process. To be sure, there are examples where effluent and ambient water bioassay results are congruant. But examples exist in the literature (Lee and Jones, 1986) where ambient water testing showed ammonia toxicity not to be a problem when effluent testing alone would have indicated a problem. Conversely, ambient water bioassays have detected in-stream toxicity downstream of a mixing zone that was indirectly attributed to ammonia (Lee and Jones, 1987) but would not have been predicted from effluent ammonia concentrations. In this case, stream conditions were facilitating a buildup of toxic nitrite ions from incomplete nitrification of ammonia.

Although acute bioassays offer a relatively straightforward means of assessing the short-term trace effects of ammonia or chlorine in laboratory tests, the potential effects on sensitive life stages are frequently of greater ecologic concern in a particular receiving water. Standard laboratory test protocols for a variety of fish, invertebrates, and plants exist and form the nucleus of a strategy for assessing ambient problems. Fish and invertebrates are probably the most important of the test species available for ammonia or chlorine assessment.

Chlorine measurement and removal in effluent and ambient water samples are straightforward for laboratory assessments using chronic bioassays, and a number of example experiments exist (Newbry et al. 1983; Heath, 1978; Burton et al. 1980; Thomas et al. 1980; Heinemann et al. 1983). Ammonia control, on the other hand, may not be easy to achieve for some effluents in chronic tests. Daily adjustment with acid or base (Peltier, 1978) to the desired pH can be performed during the sample renewal step required in most protocols; however, if this fails to hold the pH, incubation of test vessels in a CO_2/air chamber throughout the test may be necessary. Although there are alternatives for ammonia removal (ion exchange, high pH air-stripping), they are not generally desirable because they remove other toxicants.

Field Studies

Laboratory test results for acute and chronic toxicity evaluations of effluent and ambient receiving water are not necessarily accurate predictive tools in themselves to determine whether ammonia or chlorine have a biologically significant impact on a receiving water ecosystem. Effects of sunlight, temperature, water chemistry, or other stream contributions may mitigate efforts to predict from laboratory assays alone. A number of useful methods are available to augment lab toxicity testing, including in-stream bioassay testing and ecological evaluations of species biomass and diversity.

In-stream testing using fish cages has been described by Heinemann et al. (1983) and others for assessing both acute and chronic effects of toxicants discharged to different receiving waters. Fish and shellfish are commonly used as test organisms. Careful monitoring of pH, temperature, salinity (estuarine) or hardness (fresh water), and toxicant concentrations are necessary to evaluate the effects of chlorine residual or ammonia. Endpoints in these assays are usually limited to mortality or growth. Toxicant control for in-stream experiments analogous to those conducted in laboratory tests (dechlorination or pH adjustment) usually will be limited to control measures that can be exercised in the treatment plant prior to discharge. Use of in-stream cages can facilitate time of exposure or point of impact experiments with specific animals. Other in-stream experiments have had innovative designs omitting the cages. For example, those by Grieve et al. (1978) used fish implanted with transmitters to map fish avoidance of intermittent chlorine residual plumes.

A variation of the in-stream cage tests lends itself to some direct control of parameters. This variation involves directing a portion of the stream or receiving water through test tanks. Such a continuous flow sidestream can be dechlorinated or pH adjusted to control concentrations of chlorine or ammonia. Test endpoints can be somewhat more flexible here. Fish respiration rates or other subtle indications of organism stress to monitor an effect of a discharge can be used, but caution must be exercised so that an ecologically significant endpoint is measured for a particular site.

Perhaps the ultimate description of biological significance rests with ecological studies and biomass enumeration. Such studies may range from a relatively simple fish habitat-census study (Lee and Jones, 1986) to a more complete enumeration of species number and diversity in sediment, water column, and shore and intertidal communities as routinely performed by the County Sanitation Districts (Stull et al. 1986). Design and interpretation of these sorts of studies must recognize impacts of such variables as severe storm runoff and scouring, seasonal temperature variations, recruitment and settlement patterns of indigenous organisms, and other site-specific variables.

Standard Methods (1989) provides a good overview of methods and references applicable to the biological examination of waters. The value of such studies can be great. In the example cited (Lee and Jones, 1986), no readily discernible difference was observed between the numbers and types of fish in a predicted (from laboratory tests) zone of potential chronic toxicity and a study area outside of this zone. It was determined in this and related studies that adding nitrification to the treatment process would have no impact on the beneficial uses of the receiving waters (Lee and Jones, 1986).

There are, however, clear examples of community structure assessments that have detected in-stream impacts that were not predicted by effluent monitoring and specific chemical analysis (for example, Marcus et al. 1988, where ammonia was not implicated as a cause, but rather a suite of priority pollutants and metals was discovered and linked to estuarine community degradation).

In any instance where chemical analyses of effluent and ambient water laboratory assays, in-stream monitoring, and aquatic community studies indicate that further treatment steps (such as nitrification to remove ammonia) are required to alleviate toxicity impacts on beneficial receiving water uses, follow-up investigations to monitor the results of treatment improvements are recommended. These monitoring steps may be as simple as effluent and ambient water toxicity screening using standard acute or chronic bioassays or may need to include community structure investigations.

Biological Assessment Versus Numeric Limits Regulation

A detailed examination of the basis for either a case-specific biological assessment or a numeric limits approach to regulating receiving water toxicity from ammonia and chlorine could fuel an endless debate on the relative merits of each. However, the potential costs of construction and treatment to provide dechlorination and nitrification steps across the country run into billions of dollars. Clearly, costs are justified in many situations. For cases where justification is not clear, potential cost savings justify a case-specific assessment strategy. In those cases where significant environmental damage is demonstrated and remediation required, or for cases where a POTW declines the opportunity to conduct a hazard assessment, the existing water quality criteria provide the basis for numeric limits to be targeted.

The case-specific approach puts a great deal more responsibility on both the discharger and the regulator since both are in the business of protecting environmental health. The comfort of dealing with an over/under regulation is lost; in its place are the pressures of designing, conducting, monitoring, and evaluating a complicated science and engineering study. Furthermore, as is frequently the case, even the best conceived and executed study may not provide a definitive answer in a particular case. In other instances, the biological assessment may prove that deleterious conditions exist as a result of either chlorine or ammonia and that expensive treatment modification is required. In these cases, it may or may not be any solace to the utility manager who just paid for an elaborate hazard assessment to know that additional construction and operation costs are really justified and necessary. Again, however, the potential dollar expenses and environmental damage costs seem to mandate a strategy for accurate assessments.

Regulatory Considerations in Decisions to List Chlorine and Ammonia as 307(a) Pollutants

So far, this presentation has defended the position that site-specific assessment is preferable to fixed numerical limits regulation. In a regulatory setting, a biological assessment approach could be implemented by encouraging States through the use of grant money, guidance and training, and through the enforcement of existing requirements to adopt site-specific standards. The fixed numerical limits approach, on the other hand, would be exemplified by requiring States to develop statewide numerical criteria for pollutants on the 307(a) list under Clean Water Act section 303(c)(2)(B). The term "site-specific standards" (or, alternatively, "site-specific assessment") is not used as defined by EPA. In this presentation, it is a set of standards for a particular location that may not include standards for every listed pollutant if a hazard assessment shows them unnecessary to protect designated uses. EPA usually defines a site-specific standard to mean a numerical standard based on technical information different from that used by EPA to develop a national criterion for the pollutant.

The rest of this paper is an attempt to persuade the reader that the location-specific assessment and standards development approach, in practice, is incompatible with the 303(c)(2)(B) process or any other process that uses the same tactics. California's experience with the implementation of Clean Water Act section 303(c)(2)(B) is used as an illustration.

California's Experience with 303(c)(2)(B)

In California, the process of implementing section 303(c)(2)(B), which requires the State to adopt standards for 307(a)-listed pollutants, has been directed largely by cost issues. The permittee is concerned about the cost of providing additional treatment to meet standards that may be unnecessarily stringent, and the regulator is concerned about the cost of resources required for implementation. Initially, to save resources, California chose to adopt statewide standards without relating them to specific waterbodies, beneficial uses, or problems in receiving waters. At first, this appeared to be the most efficient approach, since the alternative would have required the nine regional water quality control boards to develop more site-specific standards—more related to specific uses, problems, and conditions in each waterbody.

Time deadlines associated with section 303(c)(2)(B) were another pressure. In recommending the decision to adopt statewide standards to satisfy the requirements of 303(c)(2)(B), the State Water Resources Control Board staff issue paper stated:

> *The reason for this recommendation is concern about lack of resources to accomplish the task in the time available, and a perception that it would be more efficient to undertake this task once at the State Board rather than nine times at the Regional Boards. Historically, the adoption of even small numbers of water quality objectives has been a very time consuming process. The adoption of the large number of objectives required by the Act is a formidable task* (State Water Resour. Control Board, 1989).

At the time that this document was written, two of the three years allowed for the development of objectives had already elapsed. Perhaps if the State or the regional boards had started developing appropriate site-specific standards as soon as the Clean Water Act was amended in February 1987, they might have been able to complete the task near the deadline of February 1990. However, a long time was spent on the learning curve; therefore, resources were not available or were not perceived as being available. As it now stands, statewide standards have not been adopted, and significant issues remain unresolved. Once standards are adopted, many will be so inappropriate for specific situations that regional boards will still be faced with developing site-specific standards and performing use attainability analyses, although they do not have the resources. Thus, the process is coming full circle.

Certain EPA national or regional policies have exacerbated the problem of insufficient resources to develop technically defensible location-specific standards. One is the EPA Region IX's policy of requiring States to prove that every pollutant that is discharged to any waterbody is not and never could be a problem before States can choose not to adopt a standard for the pollutant. The assumption is always guilty until proven innocent. So many negatives must be proven that attention and resources are deflected away from pursuing real, identifiable problems.

Specifically, Region IX stated:

> *As a matter of EPA Regional policy, Region IX will presume that all priority toxic pollutants for which EPA has published criteria are present in the State's waters, unless the State documents that a specific pollutant could not be present with a thorough review of all available data. In addition, the Region will presume that pollutants present in the State's waters could interfere with beneficial uses, unless the State positively establishes that this is not the case for particular pollutants* (Takata, 1990).

If the State had wanted to take a location-specific approach rather than a statewide approach or even to blend the two approaches, how could it realistically have been expected to prove that each of the 126 priority pollutants in each of hundreds of waterbodies could not possibly be present and could not possibly interfere with beneficial uses? EPA could always argue that existing data were insufficient. As a result, statewide standards for every listed pollutant became essentially mandatory and known, serious problems have received no more attention or emphasis in the process than presumed ones.

California does have a program—not a perfect one, but a toxic substances monitoring program that does seem to work as far as identifying problems with fish tissues and sediment contamination. One would think, given the general insufficiency of regulatory resources, that these available data would have played a significant role in the 303(c)(2)(B) process. It was not so. For example, the County Sanitation Districts of Los Angeles County are faced with *Gold Book* standards and permit limits for mercury based on criteria to protect against bioaccumulation, when a fair amount of tissue sampling data clearly shows no mercury contamination of fish or shellfish in the receiving water. We are told that if the mercury number is unattainable, we can develop a site-specific criteria number (as the term is used by EPA). The problem with this is that while we are developing an alternate number, we would be in noncompliance with the statewide number. In addition, we do not see the need to develop a site-specific number (as the term is used by EPA), and we are not sure that we can do a better job than EPA for mercury.

EPA's *Gold Book* section for mercury states that a reality check is necessary because of all the complexities and conservative assumptions involved in deriving criteria for mercury. "Existing discharges should be acceptable if the concentration of methylmercury in the edible portion of exposed consumed species does not exceed the FDA action level" (U.S. Environ. Prot. Agency, 1986).

In the County Sanitation Districts' case of discharge to the San Gabriel River, fish tissue data from 1983–89 show total mercury levels below not only the FDA health criterion but also the National Academy of Sciences predator protection level and the Median International Standards. The levels were at what the State Water Resources Control Board staff considers "background levels." In this case, the answer is not for the discharger to try to develop an alternative criterion, it is to <u>not</u> adopt one when there is no threat of interference with beneficial uses. But the 303(c)(2)(B) process in practice has not incorporated this sort of reality check.

Conclusions

Any effort to regulate ammonia and chlorine as 307(a)-listed pollutants will also trigger the 303(c)(2)(B) State standards-setting process. Federal regulators may view this positively because it will refocus attention on two toxic pollutants that can create real, identifiable impacts in receiving waters. Their significance, however, depends on the size of the impact area and the likelihood that significant aquatic species will be in that area long enough to be affected. These factors determine the impact on beneficial uses and are site-specific. The 303(c)(2)(B) process has not effectively taken site-related factors into account.

The question, then, is whether there is a regulatory alternative to the 303(c)(2)(B) process that would focus attention on ammonia and chlorine so that real problems will be identified and fixed. The whole effluent toxicity and in-stream monitoring approaches are good alternatives provided that some of the technical problems discussed earlier are resolved. Even the Federal regulatory water quality standards framework as it existed prior to 303(c)(2)(B) could be used to control chlorine and ammonia. After all, the only new thing that 303(c)(2)(B) did was establish deadlines for adoption of standards that should have been adopted anyway. Since the deadlines were not accompanied by additional resources, and since States spent so long on the learning curve (indeed, are still on the learning curve and will be there for some time to come), the result was an involved and confusing situation.

It is equally important to avoid requiring statewide ammonia and chlorine standards using a regulatory process that is just 303(c)(2)(B) by another name. An example would be adding a requirement to Agency guidance that would pressure States to adopt statewide standards. Addressing ammonia and chlorine through that process would not promote the sort of site-specific approaches that are necessary to achieve adequate protection at a reasonable cost to both the discharger and the regulator.

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Regulating Chlorinated Organic Pollutants

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Introduction

Earlier in this conference, Dr. Geraldine Cox of the Chemical Manufacturers Association (CMA) talked about the gross pollution of 20 years ago. As she said, "You don't *see* that anymore." For what may be the only time today, I want to express agreement with CMA. We don't *see* the gross pollution anymore. Out of sight, out of mind.

According to Dr. Cox, risk assessment should be "purged of conservatism." My contention is that risk assessment—and the water quality program—should be purged of its unjustified policy liberalism and should stop ignoring important scientific relationships.

Ignoring Toxicological Equivalencies

In the States, the Clean Water Act's § 304(l) program has been implemented almost entirely on the basis of single-number water quality standards that, in the case of 2,3,7,8-TCDD, for example, completely ignore the cumulative effects of toxicologically equivalent and additive compounds. Science now understands that many dioxins, dibenzofurans, and co-planar PCBs act on the same Ah receptors in cells—they have the same keys fitting into locks that switch on enzyme activity.

The U.S. Environmental Protection Agency (EPA) and the North Atlantic Treaty Organization (NATO) and Nordic countries have all come up with toxic equivalency factors (TEF) that allow calculation of the overall potential impacts of part of the chlorinated organic compounds in a discharge stream. Yet, the TCDD water quality criteria document still talks as if the world were a tightly controlled laboratory experiment, with all variables except TCDD ruled out. The States have adopted water quality standards for TCDD that make the same fundamental error. The permits issued under the 304(l) program make the same mistake; they ignore toxic equivalencies.

Here is an example that illustrates the seriousness of this problem. In the Columbia River behind Grand Coulee Dam, fish sampled last year had 4 ppt of TCDD in the fillet, after the skin and viscera were removed. Under EPA's TCDD criteria, that works out to about 60 times over the one-cancer-per-million level for people who would eat such fish. Moreover, 4 ppt is the only figure that receives policy attention even though the same fish had 320 ppt of 2,3,7,8-TCDF—a dibenzofuran and about the fifth most toxic chemical compound known to science—with 1/10 the toxicity of TCDD.

The TEF formula of both EPA and NATO counts the 320 ppt of TCDF as being toxicologically equivalent to 32 ppt. Adding that 32 ppt to the 4 ppt of TCDD, we get 36 ppt—nine times as high as the TCDD figure alone or 500 times the one-cancer-per-million level. (And that does not even consider the fact that the Colville Tribe owns half the shoreline of that part of the Columbia River in Washington, that American Indians eat 10 to 20 times more fish than the rest of the population, and that they sometimes eat the *whole* fish, including the even more highly contaminated body parts, which scientists cut off before performing sampling.)

Ignoring Total Environmental Load

Willful ignoring of factual evidence goes much further. The eight chlorine-using pulp mills in the United States and the additional one across the border in Canada that discharge TCDD and TCDF are being regulated on the basis of a total maximum daily load (TMDL) for the Columbia River system as a whole. But EPA Region X and the States have completely ignored all sources of dioxins (and, for that matter, furans and PCBs) except the pulp mills; they have ignored municipal sewage plants, wood-preserving plants using pentachlorophenol, the old Agent Orange factory in Portland, and various Superfund sites.

It is as if diabetics were to avoid only putting sugar into coffee, while eating chocolate sundaes without limit. Some things can occur only if processed through the magic of governmental risk assessment, where we make decisions for others and where there is heavy quasi-scientific lobbying by groups that manufacture products such as chocolate.

The Shift from Alternatives Analysis

Change is possible. So are improved policies. Even radical shifts in our paradigms are possible: how we view the world, what we think is possible as an alternative future. A good paradigm shift was the revolution started in 1962 by scientist Rachel Carson in her book, *Silent Spring*. Another good one was the creation of EPA and the avalanche of changed Federal environmental statutes following Earth Day 1970.

EPA had the following policy in the early-to-mid-1970s in its pesticide program: if a pesticide caused cancer, it was banned if there was any viable alternative (though admittedly rarely, and only after years of legal hassle from the producers of the pesticide and their allies in the U.S. Department of Agriculture). William Ruckleshaus did it, Russ Train did it, and Doug Costle did it, as late as 1979 in the case of 2,4,5-T.

A bad paradigm shift was the rise of quantitative risk assessment, a pseudo-science of oft-hidden assumptions that mask subjective policy behind a facade of seemingly objective, computerized printouts. The evil twin of quantitative risk assessment is the doctrine of acceptable risk—and it is a doctrine, which means an ideology, which means it is either political or religious, depending on its advocate. We are not talking here about risk decisions that we make for ourselves, but about ones we make for others. For ourselves, we have the right to make any decisions that we choose concerning acceptable risk. We have to make such decisions; this is not a risk-free world. We can even make quantitative decisions for our personal, day-to-day behavior, but we must move carefully when making such decisions for others in the ideology of acceptable risk (perhaps William Ruckleshaus' worst legacy in his post-Gorsuch reincarnation).

We should make decisions of *acceptable* risk only with great humility and respect for the God-like powers we are exercising. To make these decisions casually or with hubris, and to make them without full disclosure of the incredible inadequacies in the data we are using and the incredible arbitrariness in the assumptions that go into the mathematical models, is an offense against fellow human beings.

Alternatives to Chlorine

I want to talk about EPA rediscovering its roots and returning to the policy of banning risky substances if alternatives exist. Join me in imagining the steps that would be required to phase out all or many of the uses of chlorine in our society and certainly in some industries. Now that sounds like an extreme proposal, doesn't it? Yet it has been proposed by the courageous scientists on the Great Lakes Science Advisory Board of the International Joint Commission, a U.S.–Canadian intergovernmental body. A Canadian newspaper account of the group's October 1989 report put it this way: "The scientists finally got mad." (It puts a whole new meaning on the phrase "mad scientist," I think you'll agree.)

This "extreme" proposal is also one forthrightly stated by the Swedish Minister for the Environment, Birgitta Dahl. In 1989, she said, "By the year 2000 we shall get rid of it," meaning chlorine use in pulp and paper mills. This June (1990), the magazine *Oil and Forestry* wrote: "Consumption of chlorine is forecast to reach the zero point by 1995, where in 1960 it stood at over 100,000 tonnes."

And what does paper look like if it is produced without any chlorine—not even chlorine dioxide? Here is one example: a full-color magazine from *Greenpeace*, which now imports chlorine-free paper from Europe as a demonstration project. Also, white copy machine paper is made in Austria without any use of chlorine or chlorine dioxide.

Just think of it: no chance of forming dioxins, no chance of forming dibenzofurans, no chance of forming chlorophenols, chlorocatechols, chloroguiaicols, chloroveratrols, or any of the 1,000 to 3,000 chlorinated organic compounds found in pulp mills and discharged into our rivers and lakes. Does anyone here really believe our toilet paper needs to be white, as opposed to a slight off-white?

DES and Hubris

I have talked of a paradigm shift. In thinking about the possibilities for consciously driven changes in our ways of thinking, I decided to rummage around for old books, to see what kinds of changes have occurred since I went away to college, too many years ago. Here is a little volume by Dr. Isaac Asimov called *The World of Carbon*. The date, like that of *Silent Spring*, is 1962. He has just described the benzene ring—six carbon atoms in a hexagon, with hydrogen atoms sticking out around the hexagon. Then he describes how two or more benzene rings can lock together at the corners, forming other compounds.

One passage caught my eye. Remember, this is 1962:

> *An interesting phenol with medical importance is diethylstilbestrol . . . [You've probably heard of this one, known primarily by its abbreviation: DES.] . . .*
>
> *. . . [I]t is possible to manufacture some . . . hormones synthetically in the laboratory. It is even possible . . . to manufacture some other compound . . . which will have the same effect as the hormone. [Diethyl] Stilbesterol is the most successful example. It was first introduced in Europe in 1939 as a substitute for female sex hormones,* **and in some ways, it actually works better** (p. 83, emphasis added).

You see how easy it is to fall into the sin of pride —hubris—about the achievements of chemistry.

The Great Law: Protecting Future Generations

I'm going to stray from the chlorine world for a moment, but the point will be applicable to it. The use of DES violated a law. Not a law of the U.S. government, but rather what is known as the Great Law of the Six Nation Iroquois Confederacy. I think you will find that it would be difficult to reconcile this law with quantitative risk assessment, with present-day decisions of acceptable risk, even with numerical water quality standards for persistent bi-accumulative, toxic, synthetic compounds. The law says: "In our every deliberation, we must consider the impact of our decisions on the next seven generations."

Unfortunately, nobody inside the Beltway is applying that law. It is, perhaps, not sophisticated enough, too primitive, suited only for a primitive people.

DES did not appear to harm the pregnant women to whom it was administered as a morning sickness medicine. For them it was, as Isaac Asimov said, "the most successful" synthetic hormone. For them, "in some ways, it actually work[ed] better." For some of their daughters, who did *not* take DES, it became a living hell. In those daughters it caused cancer—a rare form of vaginal cancer. How did the DES get into their bodies?

The Perfect Environmental Crime: Harming Offspring

While we are talking about the law, let us talk about crime. What would be the perfect crime — the one that allowed the perpetrators the opportunity to escape, maybe even to die of old age, before its existence even came to light? This hypothetical perfect environmental crime would use, as the weapon, a poison that did not even seem to be a poison, perhaps not for generations. Its effects, in short, would be "sub-lethal" to its first consumers. Perhaps it would act indirectly; for example, by suppressing the immune system. Perhaps it would skip generations. Perhaps the weapon would be a contaminant that caused behavioral and intellectual defects rather than apparent physical defects in offspring—in our children—and these effects on behavior would be masked because the mothers might just think that their infant falls naturally where it does on the bell-shaped curve of human variability. Wouldn't it be deliciously difficult to uncover the perpetrator of this perfect crime if, through generation-skipping effects, indirect effects, and behavioral effects, it was difficult even to notice the corpus delicti?

Recently, a 14-year-old girl died from a rare form of vaginal cancer, the one that is a pretty reliable fingerprint of the work of DES. The child never took DES, though. And her *mother* never took DES. But DES had been prescribed to her grandmother, back in that age when DES was considered, in Isaac Asimov's words, a "successful" substitute for female sex hormones "and, in some ways, it actually works better." How did the DES get into her mother, and how did it get into her?

Let me return to those benzene rings, joined together and sprouting little prickers of chlorine atoms on some of the free corners, as, for example, dibenzo-dioxins, dibenzofurans, or chlorinated biphenyls. And let me use descriptions that are more understandable than dry, scientific papers.

The effects caused by these compounds have been well and clearly described in an article published last fall in *Buzzworm: The Environmental Journal*. The article has just described how the march of cells in the creation of a new bird from a fertilized egg can be tripped up by the bad timing caused by PCBs in the egg, causing birth defects—teratogenesis.

> *In whole populations of birds throughout the Great Lakes the embryonic timing gears have been sabotaged. It is as though some vandal had tossed a fistful of metal shavings into the exquisite, biological clockwork that is the egg. . .*
>
> *There is nothing—nothing—in the biology of the egg that knows how to cope with a PCB thrown into the works. Until recently no embryo ever had its timing tripped up by this molecule—not in all the years since Class Aves evolved from the flying dinosaurs of the Cretaceous period, 100 million years ago. This molecule first appeared abundantly on the earth in 1929. It may never go away.*
>
> *We made it that way.*

The article quotes scientist James Ludwig: "There is the 'Murder, She Wrote' kind of poisoning, where people clutch their throats and fall down dead.Then there is *this*."

Chlorinated organic poisons are, you see, poisons that even Agatha Christie might not discover until it is far too late. They can be subtle, indirect, perhaps delayed in effect, yet incredibly persistent. Chlorinated organic compounds are the gifts that keep on giving.

Phasing Out Chlorine

I love flying to D.C. from my house in Oregon. As I crossed the Rockies in northern Colorado, I looked down on a small town with a few city blocks nestled around a crossroads. The gentle snow glistened in bright sunlight. How many millions, billions, zillions of individual snow flakes went to make up the view from just one window of one cozy house, I wondered. The thought drew me inside one of the houses, and I imagined myself lying under a warm down quilt, looking out that window, logs crackling in the fireplace to take the chill off the morning air.

I wondered about the neighbors, Bill and Jane (my fantasy began to put names on the inhabitants of that peaceful scene). Jane was five months pregnant, I decided. New life was stirring in her womb — millions, zillions of molecules. Each hour, each minute, her body pumps life-giving nourishment to the fetus. Each hour, each minute, her body pumps polychlorinated biphenyls, polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans across the placental barrier, through the umbilical cord, and into the infant. Millions. Zillions of molecules.

What can we do to institute a true paradigm shift in our environmental policies that regulate the new, exciting chemicals that are sold to us as working better than the ones bequeathed to us by millions of years of human, mammalian, and other evolution? How can we avoid more DES stories, particularly in the chlorine world? How can we, in our every deliberation, consider the impact of our decisions on the next seven generations?

In March 1990, the International Joint Commission (IJC) published its Fifth Biennial Report on Great Lakes Water Quality. Here is what this staid government body printed on its cover: "The child that I am carrying right now has probably, and is currently receiving, the heaviest loadings of toxic chemicals that it will receive in its lifetime."—Eminent Scientist, 1989 Biennial Meeting.

Inside, the IJC said this, among other things:

> *In recent years, cancer has reigned supreme among diseases which frighten human-kind. . .*
>
> *Now we are confronted with the knowledge that more subtle disease and dysfunctionality outcomes occur from living organisms' exposure to toxics in addition to—or rather than—malignancies . . .*
>
> *The Great Lakes have been a rich source of such data, yielding information that a number of serious impacts which are neither carcinogenic nor mutagenic are occurring in a large number of Great Lakes fish, birds, reptiles and small mammals. In most instances, these effects include population declines, reproductive problems, eggshell thinning, severe metabolic changes, gross deformities, behavioral and hormonal changes and immunosuppression. These effects occur in offspring, the apparent result of maternal transfer.*
>
> *The growing public awareness that toxics are affecting certain fish, reptile and small mammal populations raises two fundamental and sobering questions: Are humans in danger? Are future generations in danger?*

The Commission put the following in boldface type:

> ***When available data on fish, birds, reptiles and small mammals are considered along with this human research, the Commission must conclude that there is a threat to the health of our children emanating from our exposure to persistent toxic substances, even at very low ambient levels.***

In the fall of 1989, the Great Lakes Science Advisory Board of the IJC had recommended the phasing out in North America of all production processes involving halogenated compounds: chlorine, bromine, and fluorine. In March of 1990, the IJC itself, a body established by international treaty, made these recommendations:

> i. All persistent toxic substances are ultimately harmful to the integrity of the environment, both in the Great Lakes region and globally, and should not be allowed to enter the environment.
>
> ii. Persistent toxic substances find their way into the environment in many ways, through production, residuals discharge, use and destruction.
>
> iii. The technology either exists—or can, with very few exceptions, be developed at some cost—to replace (or control in the interim) the use of persistent toxic substances.
>
> iv. Sufficient information is now known for society to take a very restrictive approach to allowing persistent toxic substances in the ecosystem and to declare such materials too risky to the biosphere and humans to permit their release in any quantity. . .
>
> Substances that have important uses and for which substitutes cannot be found immediately must be produced, used and subsequently recycled or neutralized under the most stringent protective conditions to ensure they do not enter the environment. Substances for which zero discharge cannot be assured must be phased out of use as soon as possible. Target dates for the staged reduction and early elimination of these substances should be set in the very near future and strictly enforced by incorporating them into appropriate parts of the legislative program discussed below.

It may be questioned whether society is willing to bear the costs of rejecting or modifying the products and processes which create or discharge persistent toxic substances. Clearly, however, the cost of inaction or insufficient action is, in the long run, vastly greater than the cost of timely action now.

Reproductive Harm in Other Species

In California, peregrine falcons are suffering reproductive harm linked to dioxins and PCBs. (A conference on peregrines and organochlorine harm took place in Oregon in mid-January 1991.) In the Northwest, bald eagles along the lower Columbia River are suffering severe reproductive failure, linked to organochlorine contamination. Ditto for river otter and mink. For whatever reason (and organochlorines are one of the two main hypotheses), sturgeon in parts of the Columbia River have *zero* reproductive success.

Where reproduction is not blocked, behavior is being affected. Laboratory rats eating contaminated Lake Ontario salmon suffer behavioral learning effects. Rhesus monkeys fed 2,3,7,8-TCDD suffer adverse behavior effects as a result of harm to *learning in their offspring.*

EPA and the States are, of course, ignoring these disasters. They are blithely reissuing permits to dump thousands of pounds of chlorinated organics into rivers and streams based only on human cancer calculations.

Behavioral Toxicology in Humans

What about human infants? Dr. G. Fein, a toxicologist in Michigan, did a study, published in 1984, on women who had eaten <u>two</u> or <u>three</u> meals per <u>month</u> of salmon or trout from Lake Michigan. That's not very much fish, but these fish had organochlorines in them. She found that the human babies of these mothers had smaller heads than the average, the mothers had more premature births, the babies had learning difficulties, were easily startled, and had short attention spans. Similar studies have shown these effects in North Carolina.

Follow-up work was published in January 1990 in the *Journal of Pediatrics* by Drs. Joseph and Sandra Jacobson and Dr. Harold Humphrey. Of 236 four-year-old children administered a battery of memory and learning tests, 17 flatly refused to respond to the items on the 17 tests. The mother's milk PCB levels of those 17 children were significantly higher than those of the other children at the 99.9 percent confidence level. Mothers in industrialized countries pass PCBs and dioxins to their nursing infants at rates that are 10 to 100 times the World Health Organization's "acceptable daily intake." Of the children that did respond on the tests, the higher PCBs in the umbilical cord back at birth, the poorer the performance four years later on verbal and memory scales of the McCarthy Scales of Children's Abilities, a battery of cognitive tests. Prenatal PCB exposure was associated with poorer performance on subtests involving short-term memory.

The researchers concluded: "Our data indicate that in utero exposure to PCBs and related contaminants [earlier identified as polychlorinated dibenzofurans and dibenzodioxins] is associated with poorer short-term memory functioning in early childhood. This corroborates previous findings with infants [Dr. Fein's 1984 study] and indicates that the deficit is a continuing one."

They said the magnitude of the deficit is modest, and not gross impairment, but: "Nevertheless, the effect is sufficiently robust to impair memory function in different domains and different modalities."

They said, "the poorer memory performance seen in the study indicates diminished potential." They said, "short-term memory and selective attention are known to be important in the acquisition of reading and arithmetic skills. Thus, these deficits, although subtle, could have a significant impact on school performance in later childhood."

Why is this happening? The authors say:

> *Research on other teratogens suggests that migratory cells and cells undergoing mitosis [those legions of cells dividing and replicating with the precision instilled by millions, zillions of years of evolution] are sensitive to toxic insult. [The iron filings thrown into the gears of the clockwork of creation.] In addition, the fetus lacks important drug-metabolizing detoxification capacities that are found postnatally . . . Incomplete development of the blood-brain barrier further increases embryonic and fetal vulnerability to central nervous system insult.*

They say further:

> *Tanabe has argued that toxic effects from environmental organochlorine residues are most likely attributable to trace levels of certain highly toxic congeners of PCB, the effects of which resemble those of 2,3,7,8-[TCDD]—[dioxin].*

PCBs, dioxins, furans. They are different, and yet they are the same. In 1978, the U.S. Court of Appeals for the D.C. Circuit upheld EPA's ban on lesser-chlorinated PCBs, even though EPA had no evidence on their toxicological properties. There was, however, evidence on more-chlorinated PCBs. And the court ruled that, given the precautionary role assigned to EPA by the pollution statutes, the agency had the discretion to regulate on the basis of chemical similarity.

Persistence of Organichlorines in Humans

As I said at the beginning, the similarities also go outside the class of PCBs and sweep dioxins and furans in together. Dr. Wayland Swain, former head of an EPA lab in Michigan, testified in Canada in December on a proposal to build a huge new chlorine-bleaching pulp mill in Alberta. What would happen, he asked himself, if all PCBs and dioxins disappeared from the earth tomorrow—except for those already in the body of his daughter? Assume that at age 20 his daughter had a baby girl, he testified, and in 20 years more that girl had a daughter. How long would it be before the current organochlorines were not in the body of a female descendent?

Six generations. His great, great, great, great granddaughter would finally be the last, and her daughter in the year 2109 would finally be free of this plague, of these chemicals.

Six generations.

> *In our every deliberation, we must consider the impact of our decisions on the next seven generations.*

If we could stop the release of PCBs, dioxins, and furans into our environment tomorrow, we could begin to obey the Law of the Six Nation Iroquois Confederacy, though for six generations we would still be violating it.

Transformation of Organochlorines

But will it be enough to try to stop just dioxins, just furans, just PCBs? I don't believe so. One of the most disturbing things about chlorine is that once liberated it spreads around, and around, and around. It combines with organic matter. The chlorinated organic compounds form, change, reform in different identities A typical chlorine-using pulp mill, for example, will dump 40,000 to 100,000 pounds of chlorinated organics into a river *every single day.* Even the compounds that don't seem to be a problem (or that we don't know yet to be a problem) may change once they are out in the environment.

A presentation delivered at the American Paper Institute's 1990 Environmental Conference shows that the chlorinated lignin dumped in the rivers will create chlorophenols during biodegradation. The researchers describe the chlorinated lignin as "slow-release chlorophenol." They say that limitations and restrictions must be imposed on a "summation parameter like . . . AOX" — an inexpensive $100 test of organically bound halogens.

Another recent study found the formation of TCDD occurring inside organisms exposed to chlorinated contamination. Just ponder that one for a moment. Could wastewater treatment facilities be *creating* dioxin from other chlorinated constituents?

The release of chlorinated compounds into the environment is like opening a Pandora's Box. Once open, we can't shut it again, and the demons released may not even be the demons that we eventually face.

A No-Chlorine Future

I offer instead a solution. I don't doubt the difficulty of putting it into effect, but we can get started.

If there are alternatives to halogenated compounds such as chlorine, let's use them. If not, let's set a deadline, a technology-forcing deadline, to get rid of them, forcing alternatives to be developed. Let's not try to engage in absurdly fine-tuned quantitative risk assessment that ignores additive and synergistic toxicity, that ignores transformation of chlorinated compounds into more toxic forms in the environment after discharge, that ignores our incredible ignorance about even the identity of 90 percent of the chlorinated compounds coming out of major sources like pulp mills and the full range of toxic effects of those whose names we know.

Why should we seek to regulate chlorinated organic pollutants based on hunches disguised as knowledge? Why should we play the game of "acceptable risk" for the lives of other humans, when there are nontoxic alternatives to chlorine — certainly for the pulp and paper industry? Here is how Rachel Carson asked these same questions almost 30 years ago:

> *Have we fallen into a mesmerized state that makes us accept as inevitable that which is inferior or detrimental, as though having lost the will or the vision to demand that which is good? Such thinking, in the words of the ecologist Paul Shepard, "idealizes life with only its head out of water, inches above the limits of toleration of the corruption of its own environment... Why should we tolerate a diet of weak poisons, a home in insipid surroundings, a circle of acquaintances who are not quite our enemies, the noise of motors with just enough relief to prevent insanity? Who would want to live in a world which is just not quite fatal?"*

Are National Water Quality Standards Needed for Chlorine and Ammonia?

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Question 1

How significant to aquatic life is toxicity from the discharge of ammonia or chlorine relative to discharges of 307(a) toxic pollutants? Should EPA and State priorities be altered to reflect a national focus on ammonia and chlorine?

California Perspective

In 1969, over 80 percent of San Francisco Bay was declared not fishable or swimmable; by 1985, over 80 percent of the Bay met fishable and swimmable standards because of improved wastewater treatment including disinfection. In 1975, the San Francisco Bay Regional Water Quality Control Board adopted a zero chlorine discharge policy to mitigate chlorination impacts on aquatic life. Cause and effect data linking water quality improvements to this policy are unavailable. One benefit may be the reduced frequency of striped bass fish kills, which used to occur every summer in the Carquinez Strait (Wu, 1990). A 1986 study (Cech, 1986) showed that when striped bass were exposed to concentrations of both monochloramine (50 ppb) and unionized ammonia (250 ppb), they developed severe anemia, which could kill them.

Table 1 shows that the number of assessed California waterbodies has increased sixfold between 1976 and 1990. In this same period, impairments by chlorine, bacteria, or ammonia declined from 55 percent of all impaired waterbodies in 1976 to 15 percent in 1990. Table 2 displays 1990 assessment data by region, selected pollutants, and sources. Nonpoint sources accounted for nearly 82 percent of impairments caused by bacteria, ammonia, or toxicity.

The Regional Applied Research Effort (RARE) is a cooperative bioassay program that was inaugurated in 1989 between California and EPA. Table 3 is a summary of RARE project results for rivers in six different regions. Chronic toxicity to one or more test species was observed in all six rivers tested. Ammonia is suspected of contributing to this toxicity in three rivers.

Table 4 addresses the question, is California placing too much emphasis on 307(a) pollutants

Table 1.—California water quality assessments, 1976–1990 (impaired surface waterbodies—selected causes).

YEAR	IMPAIRED SURFACE WATERBODIES	TOTAL WATERBODIES ASSESSED	IMPAIRMENT REPORTED AS DUE TO: Cl_1 (1)	BACTERIA (2)	NH_3 (3)	TOXICITY (BIOASSAY)	% OF TOTAL (1+2+3)
1976	18	~300	0	10	0	0	55
1980	57	~500	0	34	2	0	64
1988	80	880	0	12	2	0	17
1990	234	1930	0	26	10	22	15

Table 2.—1990 California water quality assessment (impaired surface waterbodies—selected pollutants/sources by region).

		SELECTED POLLUTANTS/IMPAIRMENT				SOURCES	
REGIONAL BOARD	TOTAL IMPAIRED WATERBODIES	Cl_2 RESIDUAL	BACTERIA (COLIFORM)	NH_3	TOXICITY (BIOASSAY)	POINT	NONPOINT
1	8	0	0	5	0	0	5
2	16	0	2	0	0	1	2
3	51	0	11	0	0	2	11
4	14	0	2	0	0	0	2
5	54	0	2	2	12	0	16
6	59	0	0	0	3	1	3
7	6	0	3	0	4	1	5
8	10	0	0	3	3	2	3
9	16	0	6	0	0	5	6
Total	234*	0	26	10	22	12	53
% Freshwater	83.0	0	65.4	80.0	100.0	{18.5%	81.5%}
% Coastal (marine)	17.0	0	34.6	20.0	0.0		

*12 1% of 1930 surface waterbodies listed

Table 3.—California Regional Applied Research Effort Report (RARE)—annual summary (1989–1990).

Chronic Toxicity Observed*

REGIONAL BOARD	RIVERS	FAT HEAD MINNOWS (n/12)	CERIODAPHNIA (n/12)	ALGAE (n/12)	TOTAL (n/36)	%	NH_3 IMPACT SUSPECTED
1	Russian	3	1	9	13	36.1	?
3	Salinas	2	7	7	16	44.4	Y
4	San Gabriel	8	9	2	19	52.7	Y
6	Susan	4	0	9	13	36.1	?
7	New	0	9	0	4	25.0	?
8	Santa Ana	4	3	0	7	19.4	Y
Total		21 (29.2%)	29 (40.3%)	27 (37.5%)	—	35.6	3/6 (50.0%)

*Total tests/yr = 216
(6 rivers × 3 locations/river × 3 species × 4 quarterly samples)

Table 4.—1990 California water quality assessment (impaired surface waters by selected pollutant categories).

		BAYS, ESTUARIES, WETLANDS, HARBORS, LAKES, AND RESERVOIRS		RIVERS/STREAMS	
		ACRES	% OF SELECTED POLLUTANT TOTAL	MILES	% OF SELECTED POLLUTANT TOTAL
(1) Toxic Pollutants:	Pesticides Priority Organics Metals	669,585 527,418 624,972		706 750 445	
	Subtotal (1)	1,821,975	63.56%	1,901	74.3%
(2) Conventional Pollutants:	Nutrients Pathogen Indicators	412,430 631,116		267 290	
	Subtotal (2)	1,043,546	36.40%	557	21.8%
(3) "Other" Pollutants:	Ammonia Chlorine	625 N/A		97 3	
	Subtotal (3)	625	<0.04	100	3.9%
Total Impaired*		**2,866,146**	—	**2,558**	—

*Includes overlapping subtotal categories for relative comparisons compared to ammonia and chlorine? Assuming these data are representative, the answer is no. Both 307(a) toxics and conventional pollutants had far greater impact than either chlorine or ammonia. Effluent permit violations listed in quarterly noncompliance reports were also searched for additional insight. Only 85 of 1400 National Pollutant Discharge Elimination System (NPDES) permittees had permit violations in fiscal year 1989. Of these, four were for chlorine, three for ammonia, and four for toxicity. Even if all toxicity violations resulted from ammonia, only 13 percent of all exceedances would be a result of these two causes (5 percent for chlorine, 8 percent for ammonia). Ammonia toxicity has been found in receiving waters, and, while not a documented statewide problem, may be more widespread than previously suspected. Chlorine toxicity, however, has been addressed in California and is not a statewide problem.

National Perspective

A recent nationwide summary of State water quality assessments indicates that chlorine and ammonia account for less than 2 percent of impairments among 13,500 waterbodies assessed (Sabock, 1990).

STATES REPORTING IMPAIRMENT (BY CONSTITUENT) (n/50)		NH_3 (IMPAIRED SITES)	Cl_2 (IMPAIRED SITES)
(NH_3)	13 (26%)	142 (~1%)	---
(Cl_2)	6 (12%)	---	26 (0.2%)

A separate nationwide assessment of publicly owned treatment works (POTWs) concluded that 68 percent of 6,202 NPDES dischargers screened exceed their chlorine permit limits. California and three other western states in EPA Region IX supposedly had the highest predicted exceedances (91 percent). This statistic contradicts the 1990 California Water Quality Assessment, which did not list a single waterbody as chlorine impaired (Calif. State Water Resour. Control Board, 1990a).

Effluent exceedances are not causing documented receiving water impairments. Over 80 percent (by volume) of California's effluents are discharged to the ocean. In the Sacramento–San Joaquin River and San Francisco Bay–Delta, all but one of 149 dischargers consistently met their NPDES chlorine limits.

EPA's background and options paper (Sabock, 1990) deals with its regional office's attitudes toward national ammonia standards. Only two of the 10 regions (Region V and Region VII) gave proposed national ammonia standards a high priority. Dairies, feedlots, and other region-specific sources of ammonia account for the widely divergent problems and perceptions. Site-specific ammonia problems should be resolved at the State and local levels where there is waterbody-specific evidence to justify such a shift in priorities.

Question 2

What approach should EPA take to address the aquatic toxicity of chlorine through water quality standards?

- **Option 1:** Eliminate chlorine from the list of acceptable biocides.
- **Option 2:** Control chlorine discharges to acceptable levels: zero total residual chlorine in ambient waters.

Aquatic biologists would approve either option, but public health officials might favor detectable levels in effluent to control *Giardia* and other pathogens.

California Approach

California's 1990 Ocean Plan requires all coastal discharges to meet strict criteria for total residual chlorine (Calif. State Water Resour. Control Board, 1990b). Implementation of these limits is based on performance standards. A technical guideline report was prepared to help enforce the Regional Board's zero chlorine discharge policy (White, 1989). Exceedance of a performance threshold triggers one or more enforcement actions, depending on the seriousness of the incident as determined by concentration, frequency, and duration of the exceedance.

Figure 1 depicts acute and chronic toxicity thresholds derived (with appropriate safety factors) from chlorine time-concentration data (Mattice, 1977). Where mixing conditions allow a zone of initial dilution, the acute threshold cannot be exceeded within the zone nor the chronic threshold outside of it. This technical guidance is based on the Seattle–Renton system, which uses SO_2 (sulfur dioxide) as the dechlorinating agent to achieve zero chlorine control (Finger et al. 1985).

Recent improvements in dechlorination control include a sulfur dioxide membrane probe system and a submerged impeller injection system that draws chlorine or sulfur dioxide vapor (without water) to the point of application. The city of Sunnyvale has installed this system and is reported to

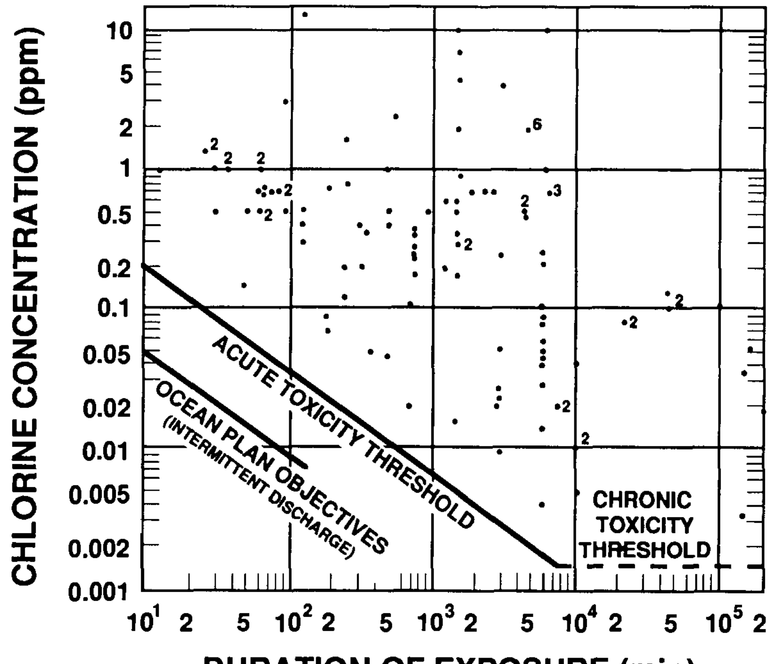

Figure 1.—Toxicity of chlorine to aquatic life (dose-time median mortality), acute and chronic toxicity thresholds (Mattice and Zittel, 1976).

have recovered its capital costs within six months. Rather than mandate national chlorine standards, EPA should support a performance-based zero chlorine discharge approach.

Intermittent Chlorine Objective

The State Board adopted the following equation in the 1990 Ocean Plan for intermittent chlorine discharge:

$$\text{Log } Y = -0.43 (\log X) + 1.8$$

Where

Y = Chlorine Objective (μg/L)

X = Time (minutes of uninterrupted discharge)

This equation applies to periodic total residual chlorine discharges that do not exceed 120 minutes with intervals of 8 to 12 hours between discharges.

The 1990 equation is more stringent than the previous (1988) Ocean Plan because of new information concerning chlorine toxicity to marine organisms. The Ocean Plan requirements for total residual chlorine are equivalent to or more stringent than the EPA *Gold Book* criteria for marine waters, which are less flexible with regard to excursion policy, allowing only one exceedance every three years on average (U.S. Environ. Prot. Agency, 1986).

Question 3

What are the major impediments to State adoption of EPA's recommendation to use Escherichia coli and enterococci rather than total and fecal coliforms as the best indicators of threat to public health?

The State Department of Health Services opposes changing the coliform standard for lack of evidence that this standard fails to protect public health. In response to a State Water Resources Control Board request to review their disinfection regulations, the Department responded: "Concentrations of *E. coli* and enterococci in waste constituents in recreational waters can differ substantially in proportion to concentrations of virus or other illness-causing organisms, from the proportions that occurred in waters recently studied by EPA. Thus, we recommend that criteria for fecal coliform be used for recreational waters rather than recommending criteria based on *E. coli* and enterococci" [emphasis added] [Womeldorf, 1990].

EPA's recommendation to change bacteria indicators was intended in part to reduce chlorine discharges and toxicity in receiving waters. This recommendation may be inappropriate for discharges to marine waters. Paradoxically, enterococci tend to persist in seawater longer than fecal coliform (Havelaar and Nieuwstad, 1985). Meeting enterococcus standards in seawater could require higher chlorine doses, thus increasing the risk of aquatic toxicity in the vicinity of the discharge.

EPA Criteria and California Ocean Plan Total Residual Chlorine Objectives

TOTAL RESIDUAL CHLORINE CRITERIA/ OBJECTIVES (μg/L)	INST. MAX.	EXPOSURE INTERVAL: HOURS 1	2	24	96	MONTHS 6
Continuous (Ocean Plan)	60	---	---	8	---	2
Intermittent (Ocean Plan)	60	11	8	---	---	---
(EPA *Gold Book*) Marine	---	13	---	---	7.5	---

Table 5.—Enterococci and total coliform comparative monitoring (% station-months attaining enterococci number or coliform standard).

DISCHARGE	MONITORING STATIONS (% ACHIEVING LIMIT/100 mL)									
	WITHOUT RUNOFF					WITH RUNOFF				
	ENTEROCOCCI				TOTAL COLIFORMS	ENTEROCOCCI				TOTAL COLIFORMS
	<24	<12	<6	<3	<1000	<24	<12	<6	<3	<1000
City of LA	100	100	89	22	85	100	62	25	13	63
LA County	100	100	100	100	100	100	100	50	0	100
Orange County	100	100	0	0	100	25	0	0	0	96
San Diego	100	100	100	100	100	25	0	0	0	96

Scientific controversy still surrounds the issue of enterococcus standards. The original epidemiological study (Cabelli, 1983) of East Coast unchlorinated waters is being used to evaluate all chlorinated discharges. Recent research using chlorinated POTW effluent and receiving waters has not generated the clear-cut trend linking enterococcus and reported illnesses that was reported in the 1983 study (Bastian and Sosin, 1990).

The World Health Organization sponsored an interlaboratory study of various pathogen indicator organisms to develop a Mediterranean Action Plan for Bathing Water Quality. One of the conclusions of this study was the unacceptably high level of false positives and negatives that occurred with the enterococcus method (Asano, 1990).

In 1988, the State Water Resources Control Board sponsored a southern California comparative monitoring study to measure both enterococcus and coliform densities at selected monitoring sites (Table 5). At stations unaffected by runoff, the enterococcus goal of <12/100 mL was achieved by all dischargers 100 percent of the time. Near-perfect compliance with the total coliform standard was also achieved at these stations. Attainment of these goals and standards was more variable at stations impacted by nonpoint source runoff, where consistent correlation between enterococcus and coliform could not be discerned. Nevertheless, continued monitoring for both enterococcus and coliform was recommended, particularly at stations that repeatedly exceed coliform standards, to help sort out the sources of these indicators.

The 1990 Ocean Plan required monitoring for both coliform and enterococcus. Exceedance of monitoring guidelines for enterococcus (<24/100 mL 30 days and <12/100 mL 6 months) can trigger a discharger sanitary survey.

In summary, the major impediments to adopting enterococci and *E. coli* as the sole indicators of threat to public health in California are institutional opposition and scientific controversy. EPA should help resolve this issue by sponsoring additional epidemiological research at selected East and West Coast sites that represent a range of disinfection and environmental variables. EPA should not mandate a nationwide enterococcus standard but should obtain sufficient information to resolve the scientific controversy.

Question 4

Should EPA review the national water quality criteria for chlorine and/or ammonia (freshwater)?

EPA criteria are expressed as four-day averages to be exceeded no more than once every three years on average. Ocean Plan objectives are calculated for a range of exposure durations from instantaneous maximum to a six-month median.

The Ocean Plan and EPA methods differ in several ways. The former method makes direct use of plant life chronic toxicity data. While the EPA 304(a) criteria are intended to protect 95 percent of the species, the Ocean Plan method is intended to protect all species. EPA criteria to protect aquatic life from chronic toxicity are based on a ratio of concentrations that cause acute and chronic toxicity in one or more species rather than the geometric mean of natural background concentrations and a "conservative estimate" of chronic toxicity. Uncertainty factors are not explicit in EPA criteria. Hence, the only way to modify their stringency is to establish site-specific objectives.

Chlorine

EPA chlorine criteria (U.S. Environ. Prot. Agency, 1985a) make no provision for intermittent exposures. California has developed and enforced Ocean Plan intermittent chlorine discharge limits since 1978.

Six years of new information are available to add to the May 1984 chlorine toxicity database. Factors such as pH, temperature, acclimation, and other chemical constituents are known to modify total residual chlorine toxicity. Although the 1984 document found no pattern consistent or great enough to justify criteria dependence on any such factor, this conclusion should be reexamined after a thorough review of new data.

The 1984 chlorine criteria document should be reexamined to incorporate six years of new data and to reconsider a more flexible excursion approach. A sliding scale of short-term acute toxicity thresholds could be based on time-concentration information used to develop the Ocean Plan intermittent criteria.

Ammonia

EPA could either require nationwide mandatory ammonia standards or use the ammonia criteria as technical guidance for site-specific applications. The mandatory approach would, if adopted, have profound economic repercussions. The 1984 criteria document should, therefore, be reexamined for significant uncertainties. These should be resolved before a costly national initiative is undertaken.

The EPA ammonia criteria document (U.S. Environ. Prot. Agency, 1985b) is replete with uncertainties and caveats. For example, on page 97:

> *Site-specific criteria development is strongly suggested* <u>*at temperatures above 20°C*</u> *because of limited data available to generate the criteria recommendation, and* <u>*at temperatures below 20°C*</u> *because of the limited data and because small changes in the criteria may have a significant impact on the level of treatment required in meeting the recommended criteria* [emphasis added].

The EPA ammonia criteria are apparently valid nationally only when the water temperature is exactly 20°C. Another crucial uncertainty mentioned in the criteria document is a lack of any information regarding temperature effects on chronic ammonia toxicity.

Research in this field has pointed out still other important data gaps (Thurston, 1988) such as exposure of biota to:

- Extreme pH and temperature,
- Natural buffering systems,
- Prior acclimation at sub-acute ammonia concentrations, and
- Short-term and cyclic "spike" concentrations.

Researchers have also conducted site-specific studies of ammonia toxicity and found that trout exposed to ammonia concentrations exceeding the EPA criterion experienced enhancement rather than impairment (Willingham and Thurston, 1985). Life cycle laboratory studies were conducted at Bozeman, Montana, to determine chronic effects of ammonia on rainbow trout (Thurston et al. 1984). At mean ammonia concentrations up to seven times the EPA criteria, no adverse chronic effects were observed.

Russo et al. (1988) pointed out some problems with the ammonia/pH/temperature toxicity matrices in the criteria document. Figure 2 shows time to death of coho salmon alevins exposed to constant ammonia concentrations and temperatures and variable pH and water chemistries. In these experiments, the optimum pH survival range is 8.7 ± 0.7; toxicity increased markedly both above and below that range. Addition of 5 percent sodium chloride significantly suppressed ammonia toxicity, while increasing sodium bicarbonate buffering increased toxicity.

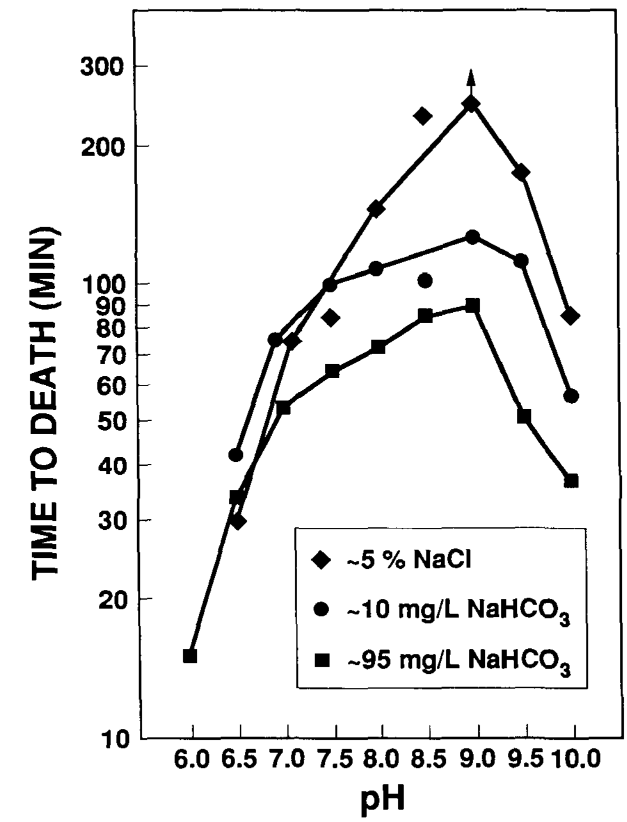

Figure 2.—pH and water chemistry variables on acute toxicity of un-ionized ammonia to coho salmon alevins (Russo et al. 1988).

Figure 3 (Thurston, 1988) shows significantly improved survival (96-hour LC_{50} values) for rainbow trout acclimated to ammonia concentrations up to 0.09 mg/L when exposures increased from 29 to 105 days. Prolonged acclimation increased fish

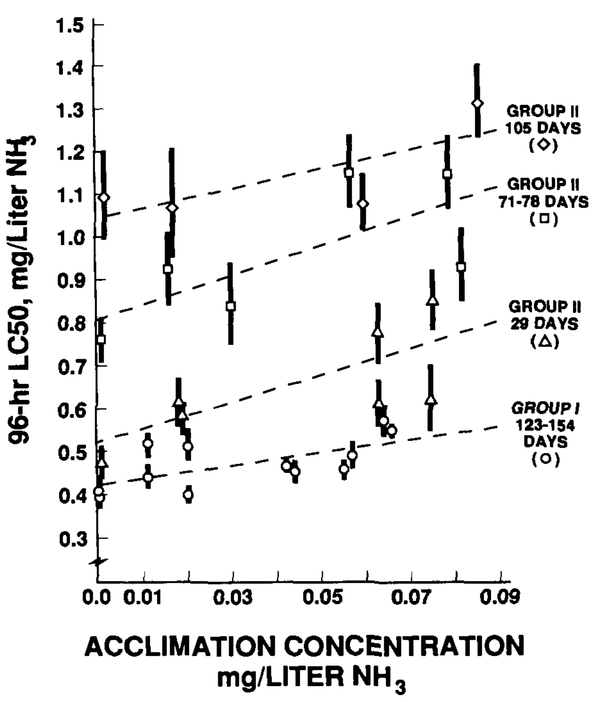

Figure 3.—Acute toxicity of ammonia versus ammonia acclimation concentration (Thurston, 1988).

tolerance to peak concentrations. Even slight reductions in dissolved oxygen concentrations increased the toxicity of ammonia to rainbow trout (Thurston et al. 1981).

The empirical equations, simplifying assumptions, and curve-fitting procedures for temperature and pH corrections of ammonia criteria were recently scrutinized (Lewis, 1988). Figure 4 shows upper and lower confidence limits for the criteria relationships between pH, temperature, and NH_3 (ammonia) criteria (LC_{50}). The zone of uncertainty ranges from 63 to 159 percent of the nominal criteria value. In other words, ammonia concentrations that deviate by 50 percent or more from the criterion table values could not be considered distinct. The degree of uncertainty in the relationship between LC_{50} and temperature is even larger than for pH. Lewis concludes that "...until the [NH_3] data base improves, the national criteria should be viewed as a set of rational guidelines from which the ideal criteria may ultimately be found to deviate considerably."

The questions raised by these studies suggest that much more research is needed before this criteria document should be relied upon to commit resources that may not be necessary. EPA should fund the necessary research to improve the national database and then use this new information to rewrite the criteria document.

Site-specific deammonification decisions should be based on the following approach:

(1) Effluent and ambient toxicity testing.

(2) At sites where ammonia is implicated as a major cause, conduct toxicity identification and reduction evaluations.

(3) Dischargers should be required to eliminate toxicity where such linkages are established.

Question 5

Would a public well informed of the risks to aquatic life from ammonia or chlorine discharges support costs for their control?

It is axiomatic that taxes in general are not politically popular. Nevertheless, during the past year California's electorate and legislature have approved several focused programs for increased spending where the benefits (improved transportation, groundwater cleanup) were directly linked to the additional costs.

The cost of municipal wastewater disinfection is less than 5 percent of the total wastewater treatment costs. Dechlorination would add approximate-

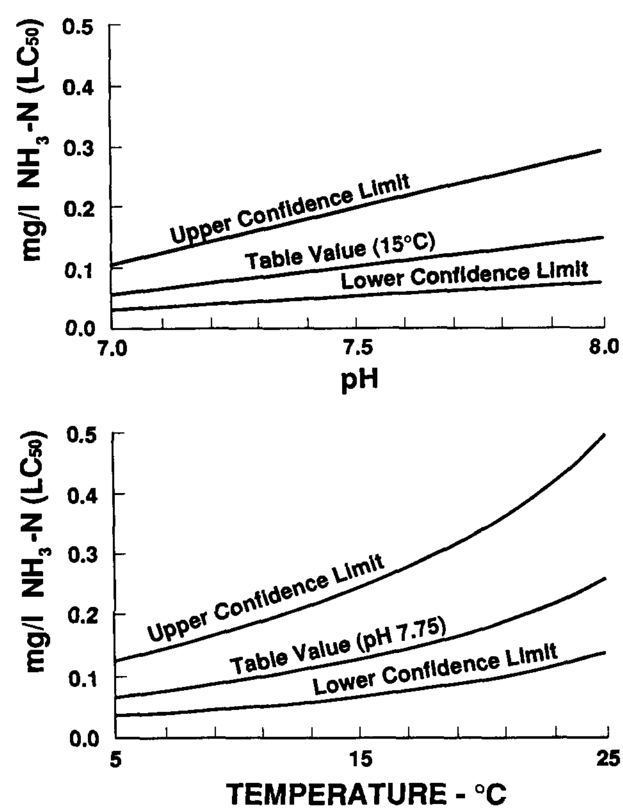

Figure 4.—Confidence limits for ammonia criteria—pH and temperature versus ammonia concentration (Lewis, 1988).

ly 20 to 30 percent to the existing chlorination costs. Under these circumstances, a well-informed public (such as in the San Francisco Bay area) would and does support a zero chlorine discharge policy and its attendant costs.

Ammonia removal (particularly two-stage nitrification and denitrification) is a much more expensive proposition (approximately $1 million per one million gallons per day) on average. Public support for such projects would probably require a preponderance of physical, chemical, and bioassay evidence of site-specific impairment. Public support in California for mandatory ammonia standards based solely on EPA criteria would, because of the previously discussed uncertainties, be low to nil.

Local public support would probably increase if the costs for ammonia removal could be offset in part by resource recovery. One example is the Tahoe–Truckee POTW advanced ammonia removal process (Dodds, 1990). In this process, which has been in operation since 1978, effluent is passed through Clinoptilite (an ion exchange media). Ammonia is extracted by sulfuric acid and converted to ammonium sulfate, which is then sold as a liquid fertilizer.

Question 6

How significant to aquatic and human life are the organochlorine byproducts of wastewater disinfection?

The majority of municipal wastewater chlorination by-products are chloramines and trihalomethanes. One notable exception involved the bleached kraft process used by the pulp and paper industry where recycled oil defoaming agents were used that contained high concentrations of aromatic precursors of tetrachlorodibenzodioxin (TCDD) and tetrachlorodibenzofuran (TCDF). When this mixture was chlorinated under conditions of high alkalinity and relatively high temperature (55–70°C), a process akin to chemical synthesis occurred. When the pulp mills subsequently obtained defoamers produced from noncontaminated oil, the concentrations of TCDDs and TCDFs (especially TCDFs) were substantially reduced in mill effluents (U.S. Environ. Prot. Agency, 1990).

The most prevalent organochlorine compounds formed during chlorine disinfection were chloroform, dichlorobromomethane, and methyl chloride (U.S. Environ. Prot. Agency, 1980). The average increase in these three organochlorine compounds was approximately 10 ppb from pre- to post-chlorination.

Less than 1 percent of all halogenated compounds found in fish exposed to halogenated sewage effluent originates from the disinfection process itself (Becking and MacGregor, 1977). Halogen reactions of this type involve oxidation of dissolved organics rather than halogen substitution reactions.

Problems associated with human consumption of fish and shellfish exposed to chlorinated municipal wastewater effluent by-products appear to be of a lower order of magnitude than direct toxic impacts of total residual chlorine to aquatic life. The proposal to phase out halogen-producing or consuming industries in North America may be a worthwhile long-term goal, but zero chlorine discharge through tightly controlled dechlorination is a more immediately implementable and cost-effective alternative.

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COASTAL WATER QUALITY STANDARDS

The Development of Biocriteria in Marine and Estuarine Waters in Delaware

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Introduction

Every two years the States must report on the status of their waters in attaining the fishable/swimmable goals of the Clean Water Act. The reporting requirements are met by determining, for each waterbody, whether State water quality standards are currently being attained. As in most States, Delaware does this by comparing water quality monitoring data with numeric water quality criteria (Del. Dep. Nat. Resour. Environ. Control, 1990a). Recently, this task has become more complex with the added emphasis on toxic pollutants in sections 304(l) and 303(c)(2)(B) of the Clean Water Act. The ultimate purpose of these assessments is to answer the simple question: "Is the water healthy enough for human consumption and aquatic life protection?"

Assessments that use chemical criteria are based on the presumption that if these criteria are not exceeded, then the uses are attained. As toxics are increasingly controlled through additional chemical criteria and whole effluent toxicity testing, regulatory agencies and the public wonder if these controls have resulted in a healthy indigenous biological community of plants and animals.

Water chemistry data and criteria are powerful tools in regulating water quality. They are used to measure the pollutant removal effectiveness of treatment technologies and quality assessments of surface and ground waters. These techniques have been and will continue to be fundamental to pollution control for point sources through discharge permits.

However, our ability to determine the overall health of natural systems is limited. As the U.S. Environmental Protection Agency (EPA) and selected States have made clear through guidance (U.S. Environ. Prot. Agency, 1990) and regulations (Ohio Environ. Prot. Agency, 1988), the best approach to assessment is an integrated one in which the strengths of each assessment tool are emphasized. Biological tools are most effective in assessing biological integrity. Where water quality problems are detected, chemical criteria are best at controlling pollution sources. Biology should not be used as the sole basis for controls, nor should water chemistry be considered the sole basis for assessment.

Numeric criteria provide a quantitative measure of performance. In a society that is driven by numbers in everything from speed limits to school grades, they seem necessary. However, the quantitative approach raises a particular dilemma for both freshwater and marine biologists—how to characterize the quality of the aquatic community numerically while recognizing the inherent complexity of natural systems. The issue is the degree to which biotic integrity can be quantified while still retaining scientific validity.

Jim Karr, who developed the Index of Biotic Integrity (IBI) (Karr et al. 1986), and others have demonstrated that numerical interpretation of natural systems can be done without sacrificing scientific validity. The IBI concept does not constitute a new approach to biological assessment. Rather, it has provided a new way of reporting the results that make it easier for biologists to communicate scientific information to regulatory agencies, the regulated community, and the public. The IBI provides a vehicle for bringing biology out of the file drawer and into the hands of decisionmakers.

Many numerically based assessment tools have been developed for marine and estuarine environments. It is up to the States to apply these tools to the management of marine and estuarine waters so that they can better answer the question: Is the water healthy?

Biocriteria Program — Delaware

Delaware is testing a numerically based biological assessment tool. This program is designed to address all types of surface waters in the State, including rivers, ditches, ponds, estuaries, and wetlands, both tidal and nontidal. Initially, it has been focused on the use of benthic invertebrates as indicators of biotic integrity.

To manage this complex task, Delaware's surface waters have been divided into four major categories that are relatively homogeneous with regard to biological conditions. This division is based on three factors: physiographic characteristics or ecoregions (Omernik, 1987), tidal influence, and sampling equipment.

These regions and the assessment strategies to be applied to them are described as follows:

- Freshwater/nontidal—piedmont ecoregion: Kick net in riffles using EPA Rapid Bioassessment Protocol III (Plafkin et al. 1989); salinity 0 ppt.
- Freshwater/nontidal—coastal plain ecoregion: D-frame net swept along banks (under development); salinity 0 ppt.
- Freshwater/tidal (under development). Salinity less than 5 ppt.
- Marine/estuarine: Depth stratified sample using box or tube cores; salinity greater than 5 ppt.

Marine and Estuarine Biocriteria Program

The program to develop biocriteria for estuarine and marine waters is initially based in the Inland Bays region of southern Delaware: the Indian River, Rehoboth, and Little Assawoman bays. This focus is in large part the result of intense development pressure in these areas as evidenced by their designation as a National Estuary Program; a 40 percent increase in population over the last 10 years; the development in 1990 of a water use plan to help manage the multiple uses of water within the watershed and the designation of the region as an outstanding water resource in State water quality standards. These designations have focused State efforts in the Inland Bays region, including nonpoint source activities under section 319 and regulated activities, including those permits for point source discharges, marina projects, and activities affecting subaqueous lands and wetlands.

The recently adopted State marina regulation (Del. Dep. Nat. Resour. Environ. Control, 1990b) has spurred the development of biological indicators in marine and estuarine systems. The regulation requires marina developments to address several living resource components: wetlands, subaqueous lands, shellfish beds, submerged aquatic vegetation, and benthic resources. The latter component requires assessment of benthic invertebrate communities using a method developed by Luckenbach, Diaz, and Schaffner (Luckenbach et al. 1988) (Fig. 1).

MARINA REGULATIONS

Benthic Resources

- "Benthic resources are protected as a matter of policy because of their importance in the food chain and their value as commercial and recreational food sources.
- The status of the benthic community must be assessed by the applicant using frequency, diversity and abundance measures approved by the Department. As a part of this determination, the rapid bioassessment techniques of Luckenbach, Diaz and Schaffner (1989) will be used by the Department to characterize benthic communities. Taxonomic and biomass data specific to this methodology shall be collected. Only areas scoring 0–3, on a relative scale of 0–8, will be considered for marina siting. The Department may modify this methodology as experience is gained in applying these techniques in Delaware waters."

Figure 1.—Delaware Department of Natural Resources and Environmental Control marina regulations.

Delaware is in the process of testing and modifying this methodology in State estuaries. These data will be evaluated with regard to establishing numeric biocriteria in State water quality standards.

Methods

The rapid assessment technique developed by Luckenbach, Diaz, and Schaffner is based on the premise that a healthy benthic community is characterized by large, deep-dwelling organisms, primarily animals from the Annelida (worms) and Mollusca (clams) orders. A benthic community that is dominated by small animals from families that are characteristic of unstable environments is an indicator of impact or stress.

The method has been tested in the lower Chesapeake Bay and been shown to be an indicator of biotic integrity (Luckenbach et al. 1988). Sampling requires recovery of a sediment sample intact to allow sectioning with depth. The fraction in the top 5 centimeters is processed separately from the sample from 5 to 15 cm. The sample collection is rapid, requiring no more than 30 minutes at each station. The cost of lab processing is approximately $100 to $200 for each sample (both top and bottom). Numerical scores are calculated from these data and the benthic community is defined according to Figure 2.

Total Score	*Benthic Community Character*
0–1	"Poor" health, highly disturbed, early successional, poor water quality *or* other severe disturbance
2–3	"Poor" to "Fair" health, moderately disturbed, perhaps recovering community, suggestion of poor water quality
4–5	"Moderate" to "Good" health, mid-successional stage
6–8	"Good" health, undisturbed, late successional community

Figure 2.—Benthic community scoring system.

The method uses a multi-variate approach based upon three pieces of information to derive a numerical score:

- Size determination—number of animals greater than 2 cm in length;
- Taxonomic composition—number of families characteristic of stable conditions; and
- Biomass—percent of the total biomass contained below the surface of the sediment (below 5 cm).

The physical habitat quality of the sediments is also evaluated. Measurements of percent sand and percent volatile residue are made along with qualitative information on the color and texture of the sediments and the presence of submerged aquatic vegetation. Generally, the procedure is most applicable to unvegetated bottoms. Sites with submerged aquatic vegetation may require a different scoring approach. Detailed water chemistry data are not collected. Scoring is performed according to the procedures presented in Figure 3.

Phase I Scores		*Score*
Fauna present below five cm?	Yes	1
	No	0
Fauna below five cm greater two cm in maximum dimension?	Yes	1
	No	0

Phase II Scores	
Species present below five cm	*Score*
Only surface dwellers present (Spionidae, Capitelidae Oligochaeta)	0
Small burrowers and commensals, (Mactridae, Nereidae, Glyceridae Nephytiidae, Polynoidae, Syllidae, Cirratulidae, Phyllodocidae, Hesionidae, Pilargidae), but not those listed below.	1
Long-lived, large fauna (Tellinidae, Veneridae, Solenidae, Chaetopteridae, Onuphidae, Maldanidae, Terebellidae, Ophioroida)	2

Phase III Scores

% Biomass below five cm	*Score*
0 – 1	0
1 – 10	1
10 – 30	2
30 – 60	3
60 –100	4

Figure 3.—Benthic community scoring metrics.

Data Collection — Rehoboth Bay

Three types of data were considered most important for the development of biocriteria focused on benthos: benthic community, sediment type, and salinity. A review of historical data indicated that benthic resource and sediment type data have not been collected in the Delaware's inland bays since 1970 (Maurmeyer and Carey, 1986). Because of development that has occurred in the bays over the last 20 years, additional data collection was deemed necessary. The review of historical salinity data indicates that all of Rehoboth Bay is polyhaline (greater than 25 ppt). Therefore, the benthic data collected in Rehoboth Bay will not be affected by changes in salinity. Benthic resource data were collected at four stations in Rehoboth Bay in July 1990 (Fig. 4).

This initial sampling had two objectives. First, the sampling tested the sensitivity of the method. Two stations were chosen in areas of intense human activity and two in areas protected from human activity. The second objective was to define the spatial heterogeneity of the data and the variability of the

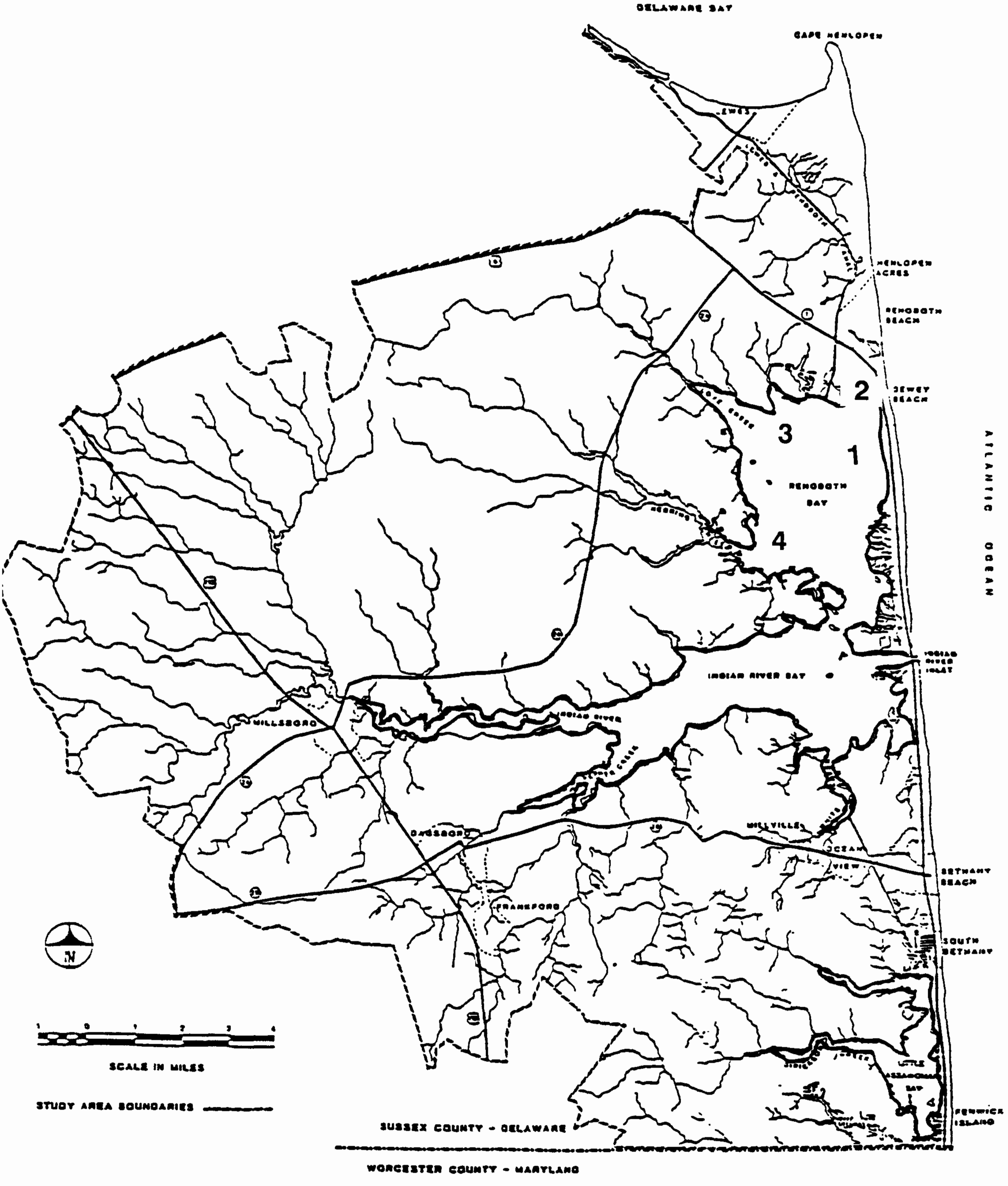

Figure 4.—Delaware Inland Bays and Rehoboth Bay sampling locations: (1)State Park; (2) Marine; (3) L&R Canal; (4) Sally's Cove.

unit sampling effort (250 sq. cm of bottom). To address this objective, three replicates were collected at each station.

Results and Discussion

The results of the scoring are presented in Table 1. The biomass and size data are presented in Table 2, while the taxonomic composition data are presented in Table 3. Several conclusions can be drawn from the data.

- Differences between impacted and unimpacted stations were not clearly distinguished. These differences would be more clearly defined by adjusting the calculation procedures. The method may need to be regionally customized.

- Numerical scores ranged from 5 to 8, or all in the "good" to "excellent" range. Station 4, Sally's Cove, was significantly better in quality with regard to the criteria calculations, number of sensitive families, and percent of biomass in the bottom fraction than the other sites.

- There is insufficient data on sediment type. Additional data on sediment type throughout the bay are needed to interpret the biological data.

- For percent biomass calculations (Table 2), there was good correlation between annelids and whole samples, except large clams were present (Station 3). Future sampling will be focused in nonshellfish areas, and biomass calculations will be made using Annelids only.

- There was a fair degree of spatial heterogeneity in the biomass and size distribution data. Surveys using a 3-replicate design at 250 sq. cm per replicate will continue to be conducted.

- The method allows comparison with historical data using straight grab sampling by combining the top and bottom fractions. Therefore, the data are easily comparable with other studies using a straight grab sampling method. A sample comparison using the Rehoboth Bay data is presented in Table 4.

Table 1.—Rehoboth Bay scores (Stations 1–4) (as revised 9/28/90).

	PHASES			
STATIONS	I	II[1]	III[2]	SCORE
State Park (sand)				
1	2	1	4	7
1-A	2	1	4	7
1-B	2	1	3	6
				$\bar{x}$ = 6.6
Composite[3]	2	1	4	7
Marina (mud)				
2	2	2	4	8
2-A	2	1	3	6
2-B	2	1	4	7
				$\bar{x}$ = 7.0
Composite	2	2	3	7
L&R Canal (mud)				
3	2	1	3	6
3-A	2	1	3	6
3-B	2	0	3	5
				$\bar{x}$ = 5.6
Composite	2	1	3	6
Sally's Cove (sand)				
4	2	2	4	8
4-A	2	2	4	8
4-B	2	2	4	8
				$\bar{x}$ = 8.0
Composite	2	2	4	8

Note: Based on Luckenbach/Diaz/Shaffner Rapid Assessment Procedure (Luckenbach et al. 1988)

[1]Families represented by the data that resulted in a one point score included four Annelids (Cirratulaidae, Nereidae, Phyllodocidae, and Syllidae) and one Mollusc (Mactridae). Families represented by the data that resulted in a 2 point score included three Annelids (Chaetoptaridae, Maldonidae, and Onuphidae) and two molluscs (Tellenidae and Veneridae).

[2]Phase III biomass calculations were based upon Annelids only due to dominance of one Mollusc in Station 3-B sample.

[3]Calculation of a single composite value for each station, based upon composite of the data for each station.

Reference Conditions

It is easy to score biotic integrity numerically as shown above. It is more difficult to set the threshold or criteria for water quality standards. Criteria are needed to determine whether actions should be taken to restore degraded conditions or maintain existing quality.

The process of setting criteria in freshwater streams has used two basic approaches: regional reference streams that are determined to be "least impacted" and upstream–downstream comparisons. Clearly, an upstream–downstream approach is not applicable to marine and estuarine systems. Therefore, establishing a set of regional references is necessary.

This approach may be problematic in that it may simply define the "best of what is left" rather than what is attainable. In other words, the "best of

Table 2.—Rehoboth Bay biomass data (as revised 9/28/90).

Macroinfauna biomass as gross wet weight, and size distribution, Rehoboth Bay, July 1990

						NO. 2 cm		% BIOMASS–BOTTOM		
	STATION	DATE	TAXON	BOTTOM	TOP	BOTTOM	TOP	ANNELIDS	WHOLE	COMPOSITE*
State Park	1	90/07/12	Annelida	0.712	0.330	9	0	68	64	
	1	90/07/12	Mollusca	0.000	0.097					
	1	90/07/12	Miscellaneous	0.070	0.007					
	1-A	90/07/12	Annelida	1.645	0.317	5	1	83	86	
	1-A	90/07/12	Arthropoda	0.000	0.001					68
	1-A	90/07/12	Mollusca	0.349	0.024					
	1-A	90/07/12	Miscellaneous	0.057	0 001					
	1-B	90/07/12	Annelida	0.501	0.425	8	2	54	53	
	1-B	90/07/12	Mollusca	0.000	0.022	22	3			
	1-B	90/07/12	Miscellaneous	0.000	0.004					
Marina	2	90/07/12	Annelida	0.748	0.450	15	4	62	61	
	2	90/07/12	Arthropoda	0.000	0.002					
	2	90/07/12	Mollusca	0.000	0.017					
	2-A	90/07/12	Annelida	0.439	0.539	5	5	45	45	
	2-A	90/07/12	Arthropoda	0.000	0.001					59
	2-A	90/07/12	Mollusca	0.000	0.005					
	2-B	90/07/12	Annelida	0.508	0.188	11	1	73	70	
	2-B	90/07/12	Arthropoda	0.002	0.012	31	10			
	2-B	90/07/12	Mollusca	0.000	0.013					
	2-B	90/07/12	Echinodermata	0.000	0.001					
L & R Canal	3	90/07/12	Annelida	0.169	0.114	7	0	60	48	
	3	90/07/12	Arthropoda	0.002	0.065					
	3	90/07/12	Mollusca	0.000	0.002					
	3	90/07/12	Miscellaneous	0.000	0.001					
	3-A	90/07/12	Annelida	0.246	0.246	1	1	50	41	
	3-A	90/07/12	Arthropoda	0.002	0.039					53
	3-A	90/07/12	Mollusca	0.000	0.078					
	3-A	90/07/12	Miscellaneous	0.001	0.000					
	3-B	90/07/12	Annelida	0.194	0.188	3	2	51	8	
	3-B	90/07/12	Arthropoda	0.003	0.066	11	3			
	3-B	90/07/12	Mollusca	0.000	2.022	*Ilyanassa obsoleta* (1 spec.)				
	3-B	90/07/12	Miscellaneous	0.000	0.007					
Sally's Cove	4	90/07/12	Annelida	1.322	0.231	6	1	85	85	
	4	90/07/12	Arthropoda	0.001	0.050					
	4	90/07/12	Mollusca	0.225	0 000					
	4-A	90/07/12	Annelida	0.658	0.149	11	0	81	82	
	4-A	90/07/12	Arthropoda	0.001	0.022					
	4-A	90/07/12	Mollusca	0.112	0.002					84
	4-B	90/07/12	Annelida	0.818	0.147	9	0	85	80	
	4-B	90/07/12	Arthropoda	0.000	0.035	26	1			
	4-B	90/07/12	Mollusca	0.020	0.021					
	4-B	90/07/12	Chironomidae	0.001	0.000					
	4-B	90/07/12	Miscellaneous	0.000	0.004					

Source. DNREC, Div of Water Resources, Dover, 1990
*Annelids, only.

what is left" may be impacted when compared to conditions within a larger region. This is especially true when assessing small systems with a limited pool of reference conditions from which to choose. For example, it is difficult to say if Station 4 (Sally's Cove) in Rehoboth Bay is impacted because of large-scale development in the region.

This type of sampling bias could drastically affect the derivation of biocriteria in estuaries and alter the technical and political decisions made to manage these resources. Unfortunately, the behavior of ambient biological systems is difficult to predict. Otherwise, we could crank coefficients into a model to tell us the biological community that is attainable under various scenarios. Clearly, an empirical or observed approach is therefore necessary.

Blindly implementing controls and observing what is attainable is costly, time-consuming, and wasteful. To date, the use of "least impacted" natural systems to derive biocriteria has worked in those States (Ohio and Maine) that have developed biocriteria. When dealing with complex natural systems, we may have no choice but to strive to attain "the best of what is left." The only question that remains is the spatial scale that is used. The pool of estuaries within Delaware is clearly not large enough, while using all the estuaries in the United States does not recognize major differences in estuaries on the Atlantic, Pacific, and Gulf coasts.

The selection of references for estuaries will require a regionally coordinated approach, not only in

Table 3.—Rehoboth Bay taxonomic data summary (indicators of good/excellent quality).

RESULTS–ALL STATIONS		(BELOW 5 CM) FOUND IN REHOBOTH BAY
Annelida		
Polychaeta	(Segmented worms)	
** 1. Chaetopteridae		X
* 2. Cirratuladae		X
* 3. Glyceridae		
* 4. Hesionidae		
** 5. Maldonidae		X
* 6. Nephytidae		
* 7. Nereidae		X
** 8 Onuphidae		X
* 9. Phyllodocidae		X
* 10. Pilargidae		
* 11. Polynoidae		
* 12. Syllidae		
** 13. Terebellidae		X
Mollusca		
Pelecypoda	(Bivalves)	
* 14. Mactridae		X
** 15. Tellinidae		X
* 16. Solenidae		
** 17. Veneridae		
Echinodermata		
Ophiuroida	(Brittle stars)	
** 18 All Families		
	Total	9

RESULTS BY STATION (TOTAL NUMBER, NUMBER OF FAMILIES)
Station 1 — 7, 2
Station 2 — 8, 3
Station 3 — 2, 2
Station 4 — 23, 4

Source: DNREC, Div of Water Resources, Dover, 1990
*1 pt score
**2 pt score

the selection of "least impacted" sites but also in the development and use of standard data collection methods. Unfortunately, coordinating the many diverse groups involved (States, estuary programs, local governments, researchers, and academics) will not be easy.

EPA can play a vital role in facilitating this coordination. Ongoing EPA programs that could contribute include the Biocriteria Development Program, the Environmental Monitoring and Assessment Program (EMAP) (U.S. Environ. Prot. Agency, 1990b) and local programs such as the National Estuary Program and the Chesapeake Bay Program. The provinces used in EMAP, as shown in Figure 5, may provide a framework for managing the development of biocriteria for estuaries on a regional scale.

The first step in this process is to draw together representatives from government, research, and academia to help standardize the collection methods and select sites for data collection, including the selection of references. In this way, data can be collected over the next several years to support the derivation of biocriteria in the future. The development of biocriteria requires a long term commitment. Through a coordinated effort, we can produce quantitative biocriteria for estuaries to help answer the question, is the estuary healthy?

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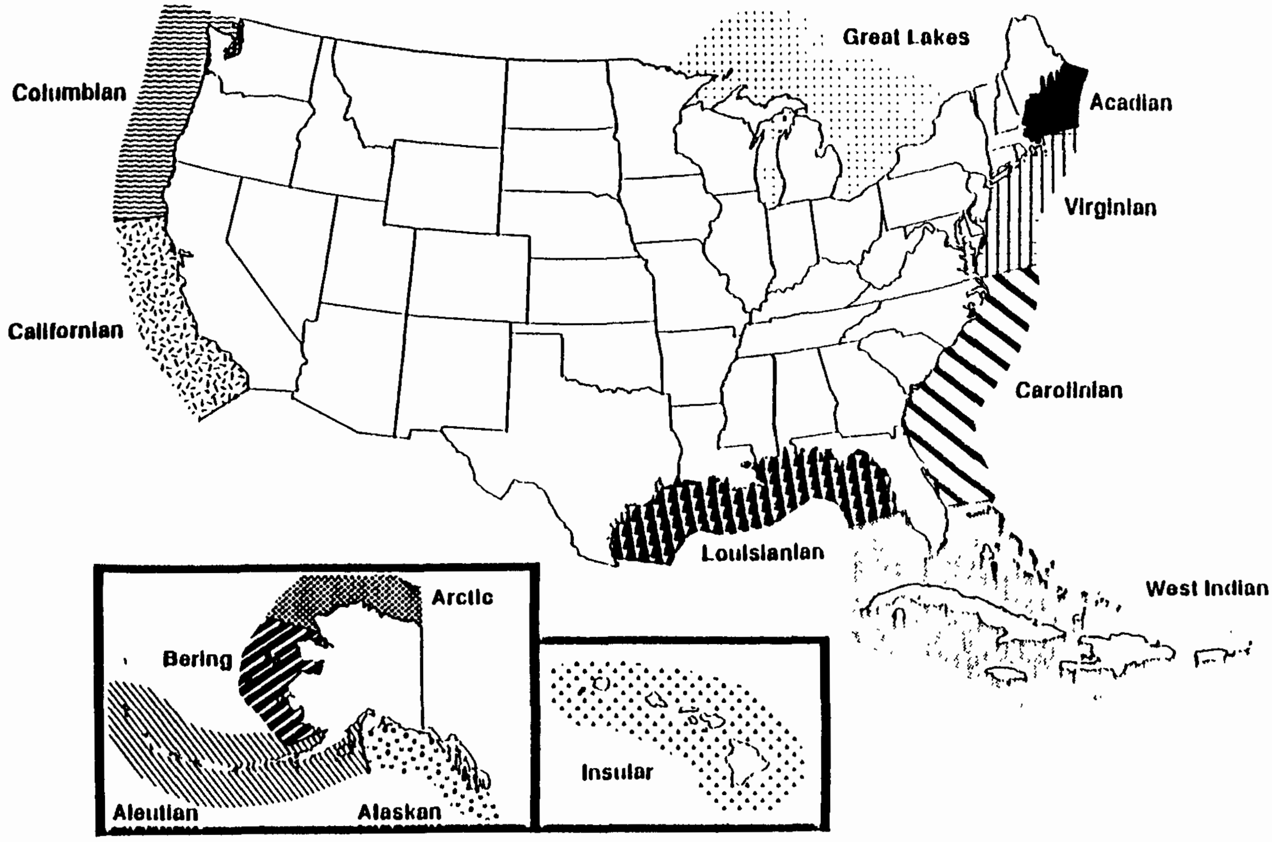

Figure 5.—EMAP Physiographic provinces.

Water Quality Standards Based on Species' Habitat Requirements
A Case Study from the Chesapeake Bay Using Submerged Aguatic Vegetation

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Introduction

A diverse array of biologically productive habitats are found in all coastal areas of the United States, ranging from upland, deciduous forests and non-tidal, freshwater wetlands to both vegetated and nonvegetated rivers, lagoons, and estuaries. Each habitat supports large numbers of permanent and transient plant and animal species.

The growth, distribution, abundance, and survival of any one species is regulated by a set of requirements unique to it that include dissolved oxygen, light, and nutrients. Each species survives within a range of values for any particular parameter below which it experiences stress and may eventually die. However, species survival depends on the integration of responses to all parameters that are important for its growth. Tolerances to one parameter (such as dissolved oxygen) may either be increased or decreased by interaction with one or more additional parameters (temperature, salinity).

A complete understanding of the species' habitat requirements is critical to understanding its response to environmental perturbations, in particular those that may affect water quality for estuarine and coastal environments. Although there are Federal and State water quality standards for rivers and estuaries, in many cases they have been generated for "fishable, swimmable, and drinkable" purposes. In general, they do not consider the unique characteristics and requirements of the multitude of species that make up a natural ecosystem.

Many of our estuaries are experiencing serious water quality problems primarily because of the pressures from the ever-increasing numbers of people moving near these areas. Most noticeable of all changes are declines in many harvestable living resources, such as fish and shellfish. Of equal concern are losses of other critical elements of the food chain that often go undetected because of inadequate funds for monitoring.

The observed declines have stimulated a major question about water quality: are declines occurring as a result of inadequate enforcement of existing standards, or are existing standards inadequate to protect the living resources? If the latter is the answer, what procedures and parameters should we adopt to adequately protect living resources?

The Chesapeake Bay Agreement

Chesapeake Bay, the Nation's largest estuary, has received considerable attention over the last two decades from scientists, managers, politicians, and the public. Declines in water quality related to increasing nutrient enrichment, high levels of contaminants, anoxic or hypoxic conditions, and changes in abundances of living resources are some of major issues facing the bay. Increasingly, scientists and managers are recognizing that, to reach the goal of a clean, healthy waterbody, we must reexamine water quality standards—specifically those new standards relating to the habitat requirements of the species living in the Chesapeake Bay.

In 1987, a historic Chesapeake Bay Agreement was signed that set as a major priority the "need to determine the essential elements of habitat quality and environmental quality necessary to support living resources and to see that these conditions are attained and maintained." The Chesapeake Bay Program's Implementation Committee called for guidelines to determine habitat requirements for the bay's living resources. A document, "Habitat Requirements for Chesapeake Bay Living Resources," first drafted and adopted in 1987 (Chesapeake Bay Progr. 1988), has been undergoing revisions to provide more detailed requirements for living resource habitat. Because submerged aquatic vegetation (SAV) is a critical part of the bay's food chain and is sensitive to water quality (Orth and Moore, 1988), it is a potential indicator of the bay's health and therefore was included in these documents.

Over the last 23 years, Chesapeake Bay's SAV has received considerable scientific attention because of an unprecedented, baywide decline of all species (Orth and Moore, 1983). This decline has been related to the increasing amounts of nutrients and sediments entering the bay as a result of the continuing, uncontrolled development of its shoreline and watershed and poor land use practices associated with this development (Kemp et al. 1983).

Both the Chesapeake Bay SAV Management Policy and Chesapeake Bay SAV Policy Implementation Plan (Chesapeake Exec. Counc. 1989, 1990) highlighted not only the need to develop SAV habitat requirements but also baywide SAV restoration goals for habitat quality, species abundance, and species diversity. In response to the commitments described in the Implementation Plan, a working group of scientists and managers produced the Chesapeake Bay SAV Habitat Requirements and Restoration Goals Technical Synthesis (Batiuk et al. in review).

SAV Technical Synthesis

The SAV technical synthesis program had three major goals:

- To develop quantitative levels of relevant water quality parameters necessary to support continued survival and propagation of SAV;
- To establish regional distribution and diversity goals for the Chesapeake Bay; and
- To document baywide applicability of habitat requirements developed through case studies used in the synthesis.

The development of SAV habitat requirements was described in four case studies spanning all the bay's salinity regimes: tidal fresh water, Potomac River; oligohaline (0.5-5 ppt), Susquehanna Flats; mesohaline (5-18 ppt), Choptank River; and polyhaline (18-25 ppt), York River (Fig. 1). Interpretation of transplant and monitoring data from the upper Chesapeake Bay and a decade of data spanning the revegetation of the upper tidal Potomac River yielded habitat requirements for tidal fresh and oligohaline SAV species. A variety of transplant, research, and monitoring studies in the Choptank and York rivers provided data to develop habitat requirements for mesohaline and polyhaline SAV species, respectively.

Through multi-investigation interpretations of findings from each of the study areas, the following

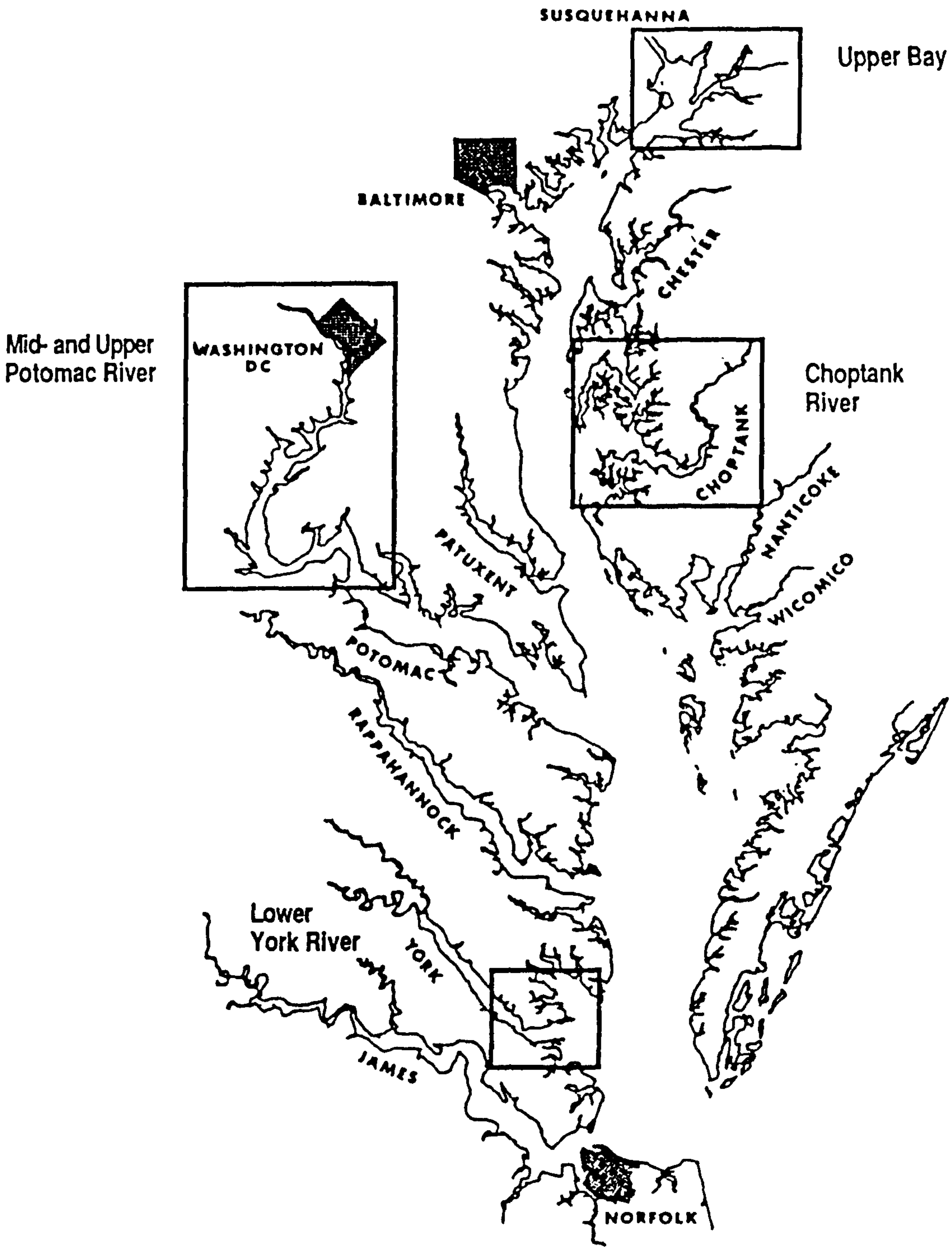

Figure 1.—Map of Chesapeake Bay showing locations of four areas used in development of SAV criteria: (left to right) mid- and upper Potomac River, tidal fresh water; Susquehanna Flats–Upper Bay, oligohaline (0.5-5 ppt); Choptank River, mesohaline (5-18 ppt); and Lower York River, polyhaline (18-25 ppt).

five SAV habitat requirements were developed for each of the bay's four salinity regimes:

- Total suspended solids (TSS),
- Light attenuation,
- Chlorophyll *a*,
- Dissolved inorganic nitrogen, and
- Dissolved inorganic phosphorus.

Restoration goals for SAV distribution were approached from a baywide and regional perspective and produced through a series of geographical over-lays that delineated potential and actual habitat. The restoration goals are reported as acreages of nearshore bay habitat that should support SAV when established habitat requirements are met. Species diversity goals were derived by comparing the potential habitat for each species based on salinity and the actual habitat as defined through recent and historical field surveys. Baywide and regional SAV abundance and species diversity goals are critical to assessing the success of basinwide efforts to reduce nutrient inputs into Chesapeake Bay.

Summary of SAV and Water Quality Relationships

The water quality parameters defined from these studies have a functional relationship with SAV growth. Interpretation of the relationships between water quality characteristics was based on basic assumptions about the interaction between the water quality parameters and SAV. These assumptions were that:

- Total suspended solids and chlorophyll *a* increase light attenuation,
- Dissolved water column nutrients stimulate growth of epiphytes and phytoplankton, which also decreases light attenuation,
- SAV survival depends on sufficient light reaching the plants, and
- Environmental factors other than those analyzed in the SAV technical synthesis do not supercede light attenuation as the major factor determining SAV survival in Chesapeake Bay.

Table 1 presents the summary of the reported work for the four different study areas. This table serves to establish the minimum water quality characteristics for establishment and maintenance of SAV populations, rather than guaranteeing conditions for colonization by a diverse, native SAV population. Water quality conditions for a diverse, native popoulation may be more rigorous than conditions that will support only monotypic and/or exotic species populations.

The data indicated that light attenuation was strongly affected by total suspended solids (TSS) and chlorophyll *a*. Light attenuation coefficient values less than 2 m^{-1} correlated with SAV survival as do total suspended solids values less than 15 mg/L and chlorophyll *a* values less than 15 µg/L. Interestingly, the data suggested an interaction of TSS and chlorophyll *a*, as there were few data where TSS were low and chlorophyll *a* values were high.

The maximum dissolved inorganic nitrogen (DIN) values supporting SAV growth were 0.14–0.28 mg/L (except for the tidal fresh and ologohaline areas) and 0.01–0.03 mg/L for dissolved inorganic phosphorus (DIP). Low values of both DIN and DIP were found necessary for SAV survival in mesohaline and polyhaline areas while, in low salinity areas, DIN did not appear to play a critical role in defining SAV habitat quality.

Restoration Goals

Results of the systematic inclusion of all areas in the Chesapeake Bay and tributaries less than 2 meters deep revealed approximately 300,000 hectares (741,000 acres) of bottom that could potentially support SAV given appropriate water quality conditions. Some of this habitat represents areas that would be highly unlikely to ever support SAV because of its exposed nature; excluding these areas yielded 250,000 hectares of potential habitat. In 1989, the annual monitoring of baywide SAV showed approximately 25,000 hectares (61,750 acres) of bottom covered with SAV (Orth and

Table 1.—Habitat requirements for the Chesapeake Bay SAV by salinity regime.

SALINITY REGIME (SAV* TARGET SPECIES)	TSS* (mg/L)	LIGHT ATTEN. COEF. (m^{-1})	CHL a* (µg/L)	DIN* (mg/L)	DIP* (mg/L)	CRITICAL LIFE PERIOD(S)
Tidal fresh *(Vallisneria americana)*	<10	<2	<15	<1.5	<0.01	April–early June; late August–September
Oligohaline *(Vallisneria americana)*	<15	<2	<15	<1.5	<0.01	April–early June; late August–September
Mesohaline *(Potamogeton pectinatus, Potamogeton perfoliatus, Ruppia maritima)*	<15	<1.5–2	<10–15	<0.14	<0.01	May–October
Polyhaline *(Zostera marina)*	<15	<2	<15	<0.28	<0.03	Spring (9°-23°) Fall (25°-13°)

*SAV = submerged aquatic vegetation; TSS = total suspended solids; CHL *a* = chlorophyll *a*; DIN = dissolved inorganic nitrogen, DIP = dissolved inorganic phosphorus.

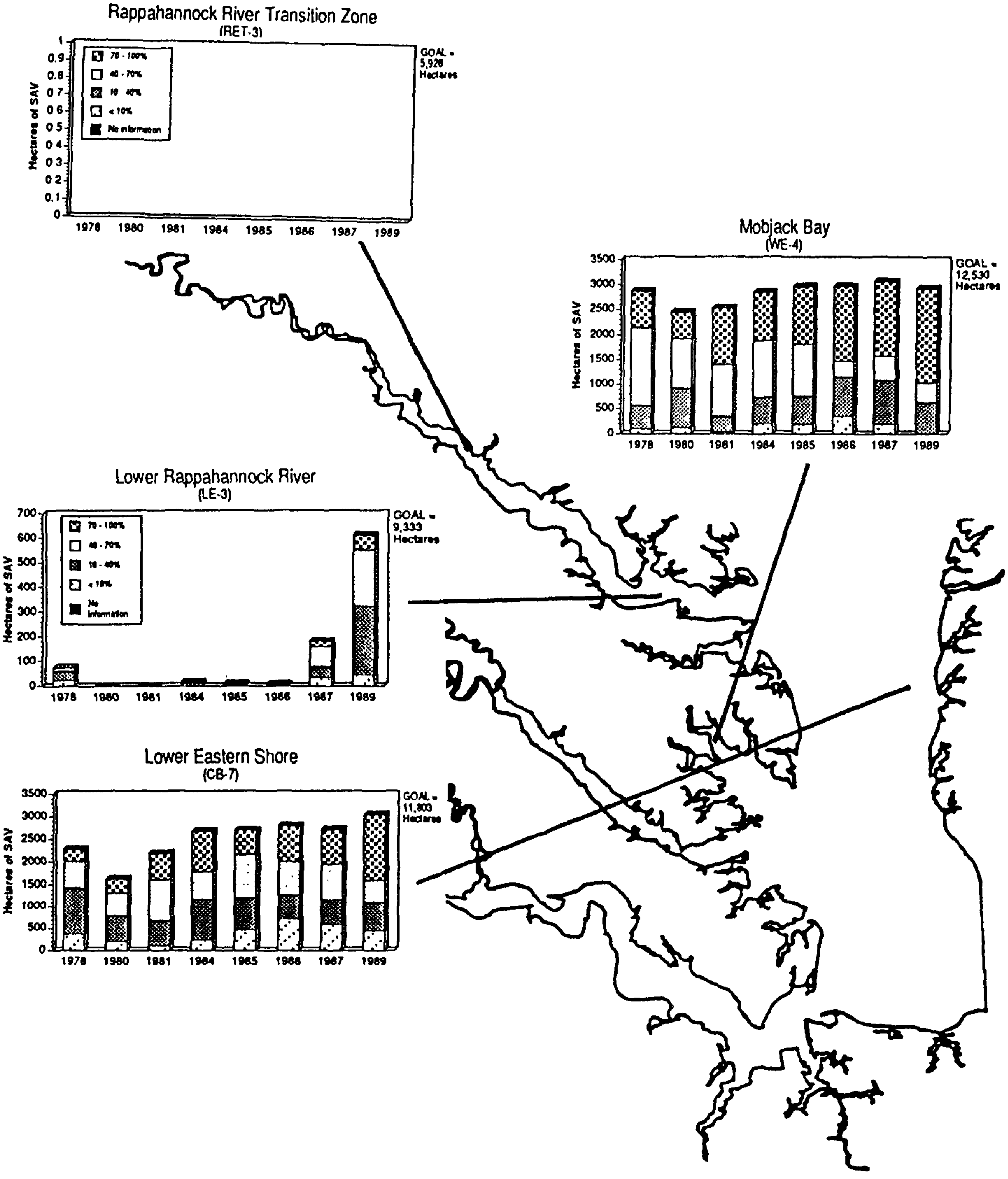

Figure 2.—Trends in SAV abundance for four sections in the lower Chesapeake Bay showing amount of SAV in different density classes (<10%, 10-40%, 40-70%, and 70-100%) from 1978 through 1989. Restoration goal for each section is presented in upper right corner of each locator box. Letter and number combination given below each location name refers to U.S. Environmental Protection Agency-derived Chesapeake Bay segment.

Nowak, 1990) or 10 percent of the potential habitat. Data for four representative sections of the bay are presented in Figure 2, which shows trends of SAV abundance for the previous decade as compared to the restoration goal for that section. Current abundance in these sections ranges from 0 to 25 percent of the potential bottom.

A comparison of SAV annual abundance patterns, habitat requirements, and water quality monitoring data from 145 water quality stations has allowed verification of the applicability of SAV habitat requirements to define conditions necessary for revegetation, survival, and growth of SAV. In 1987, 84 percent of the water quality monitoring stations characterizing areas with SAV had seasonal water quality that met four or all of the five habitat requirements. In areas where SAV was absent, 74 percent of the stations had water quality conditions that met less than four of the five habitat requirements. In 1989, 72 percent of these stations had seasonal water quality conditions that met four or all of the five habitat requirements. More than 86 percent of the stations characterizing areas where SAV was absent had seasonal water quality that met less than four of the five habitat requirements.

Conclusions

The relationships of light attenuation, chlorophyll *a*, total suspended solids, and dissolved inorganic nitrogen and phosphorus with SAV survival provide an empirically derived, real world solution to the problem of determining water quality characteristics for SAV survival. Laboratory and modelling studies have augmented the field-derived data.

One of the more intriguing elements of the technical synthesis was the close similarity in the values identified for TSS, chlorophyll *a*, and light attenuation for all salinity regimes of the Chesapeake Bay. This suggests that growth and survival of the plants, despite their location in the bay, all respond to environmental water quality within a small range of values. This response may allow for baywide management strategies rather than basin-by-basin control. However, because response to nutrient concentration depended on location (fresh water versus brackish water) nutrient reduction strategies may vary depending on the salinity regime.

The most critical aspect of this work is the relationship of these habitat characteristics to the development of revised or enhanced water quality standards to protect living resources. This is a difficult task because it requires a thorough understanding of all the sources and sinks of the different nutrients and sediments entering Chesapeake Bay. In particular, understanding the mechanisms and rates of transformation of source material to what is measured in the water column, in each salinity regime of the bay, is crucial to these revised standards.

If habitat requirements developed for SAV (or other species), such as nutrients or light attenuation, are linked to water quality standards, a different approach to developing these standards must be used other than LC_{50} measures and assessments of chronic toxicity. Understanding critical habitat requirements, manipulative field and laboratory tests of these requirements, and field validation of the experimental results is necessary to developing realistic water quality criteria for these parameters.

Lastly, there must be continuous interactions and feedback between the scientists who develop the habitat criteria for individual species and the managers who are responsible for regulations that ultimately protect, restore, and enhance the living resources. Continual monitoring of water quality and living resources, coupled with specific restoration plans and goals, is paramount if these resources are to be a part of our future.

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Water Quality Effects of Water Quality Standards Enforcement: Industrial Pretreatment in Rhode Island

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Introduction

For generations, the waters and sediments of Narragansett Bay have served as receptacles for industrial waste streams containing a variety of toxic metal and organic compounds (Quinn, 1989; Metcalf and Eddy, 1990; Nixon, 1990). With the introduction of publicly owned sewage treatment works (POTWs) at the turn of the century, much of this industrial discharge was routed through these facilities, often disrupting treatment plant operation or at least reducing treatment efficiency (U.S. Environ. Prot. Agency, 1986; Gen. Account. Off., 1989). Furthermore, several sections of the Narragansett Bay drainage basin (marine and fresh water, Table 1) currently exhibit contaminant concentrations that exceed U.S. Environmental Protection Agency (EPA) *Gold Book* water quality criteria for PCBs, copper, cadmium, chromium, nickel, and lead (Metcalf and Eddy, 1990). Levels of copper, lead, chromium, and silver in sediments of portions of the Seekonk, Blackstone, and Pawtuxet rivers are among the highest observed within the United States (King, 1990).

Table 1.—Water quality impacts of toxic loadings to Upper Narragansett Bay (Metcalf and Eddy, 1990).

SUBSTANCES	AREAS EXCEEDING U.S. EPA GOLD BOOK WATER QUALITY CRITERIA
PCBs	Blackstone River downstream of Woonsocket POTW to tidal portion of river
Cadmium	Pawtuxet River near Warwick and Cranston POTWs
	Blackstone River near Woonsocket POTW
Copper	Blackstone River near Woonsocket POTW
	Pawtuxet River near Cranston POTW
	Seekonk and Providence Rivers and Upper Narragansett Bay near Field's Point (NBC)* POTW
Chromium	Blackstone River near Woonsocket POTW
Nickel	Blackstone River near Woonsocket POTW
	Pawtuxet River near Warwick and Cranston POTWs
	Seekonk and Providence Rivers and Upper Narragansett Bay near Field's Point (NBC)* POTW
Lead	Blackstone River near Woonsocket POTW
	Pawtuxet River near Warwick and Cranston POTWs

*Narragansett Bay Commission

National Pretreatment Program

Enacted as part of the Clean Water Act amendments in 1977, the National Pretreatment Program was established to reduce releases to wastewater of toxic and hazardous chemicals from industrial processes (U.S. Environ. Prot. Agency, 1986; Sutinen and Lee, 1990). Toxic substances entering waste treatment facilities can damage treatment plant equipment (as well as sewerage collection lines), kill or degrade bacterial populations in POTWs, and possibly harm plant operators. Inhibition of POTW bacterial activity could affect the effluent and lead to violation of conventional pollutant discharge standards.

The National Pretreatment Program is implemented cooperatively through Federal, State and local governments. POTWs are required to enforce the program's General Pretreatment Regulations, which prohibit discharge of substances that:

- May interfere with treatment plant operation,
- Are not treated within the POTW, or
- May contaminate sludge (Gen. Account. Off. 1989).

The POTWs must develop and use pretreatment programs to enforce the National Categorical Standards for individual industrial users such as electroplating and metal finishing businesses (Sutinen and Lee, 1990). The categorical standards incorporate information on compounds generated by each industrial process as well as which reductions in release are economically achievable.

Rhode Island's Pretreatment Program

In September 1984, EPA delegated administrative authority of Rhode Island's pretreatment programs to the State (Sutinen and Lee, 1990). The Rhode Island Department of Environmental Management (DEM) has responsibility for oversight and approval of local pretreatment programs. Local pretreatment limits (U.S. Environ. Prot. Agency, 1987) established by several Rhode Island control authorities are outlined in Table 2.

Table 3.—Rhode Island POTWs with industrial pretreatment programs (from R.I. Dep. Environ. Manage. 1990).

POTW	LOCATION
Blackstone Valley District Commission	Seekonk River
Bristol	Upper Narragansett Bay
Cranston	Pawtuxet River
East Greenwich	Greenwich Cove
East Providence	Providence River
Narragansett Bay Commission	Providence River
Newport	Lower Narragansett Bay
Quonset Point	Lower Narragansett Bay
South Kingstown	Lower Narragansett Bay
Warwick	Pawtuxet River
West Warwick	Pawtuxet River
Westerly	Pawcatuck River
Woonsocket	Blackstone River

In 1984, 13 of the Rhode Island's 19 POTWs (Table 3), acting as control authorities, established industrial pretreatment programs. DEM prescribes compliance monitoring supplemented with demand monitoring and manhole sampling and industrial user inspection frequency for pretreatment programs (Sutinen and Lee, 1990). Of the 13 POTWs, the following have the largest numbers of categorical industrial users: the Narragansett Bay Commission (112), the Blackstone Valley District Commission (48) and the city of East Providence (13) (Sutinen and Lee, 1990).

Several studies have been conducted on the effectiveness of Rhode Island's industrial pretreat-

Table 2.—Selected local pretreatment limits in Rhode Island (mg/L) (adapted from Brubaker and Byrne, 1989; Metcalf and Eddy, Inc. 1990).

POTW	Cd	Cu	Cr	Pb	Ni	Zn
BVDC	0.4	1.0	1.5	0.1	1.5	1.2
Bristol	0.2	0.5	0.86	0.22	0.5	1.0
Cranston	ND	0.04	ND	ND	0.1	0.58
East Greenwich	0.07	1.09	1.71	0.33	0.13	1.48
East Providence*						
daily max	0.11	3.38	2.77	0.69	1.94	2.61
monthly avg	0.07	2.07	1.71	0.43	1.16	1.48
NBC**						
maximum	0.11	1.2	2.77	0.6	1.62	2.61
average	0.07	1.2	1.71	0.4	1.62	1.48
South Kingston						
maximum	0.4	1.0	1.5	0.1	1.5	—
one peak	0.8	2.0	3.0	0.2	3.0	—
Warwick	2.0	0.7	0.5	0.15	0.5	1.0
West Warwick	0.4	1.0	10.0	0.6	1.0	5.0
Woonsocket						
maximum	0.4	1.0	1.5	0.1	1.5	1.2
instantaneous	0.8	2.0	3.0	0.2	3.0	2.4

*metal finishers
**Narragansett Bay Commission
(Cd = cadmium; Cu = copper; Cr = chromium; Pb = lead; Ni = nickel; Zn = zinc)

ment programs (Brubaker, 1986; Brubaker and Byrne, 1989; Volkay-Hilditch, 1989; Sutinen and Lee, 1990). All have approached the status of industrial pretreatment from a case study viewpoint. During the early stages of pretreatment program development in Rhode Island, Brubaker (1986) reported substantial noncompliance by industrial users (with the exception of the East Providence POTW) and concluded that more than 700,000 pounds of metals were entering Narragansett Bay waters annually as a result. (This figure did not include direct industrial dischargers.) However, these conclusions were based upon compliance and pretreatment data from 1984 and 1985, before some Rhode Island pretreatment programs had been approved.

Three Case Studies

The effectiveness of the pretreatment programs operated by three control authorities (the Narragansett Bay and Blackstone Valley District commissions and the city of East Providence) were examined in detail for the Narragansett Bay Project from 1985 to 1988 (Sutinen and Lee, 1990). These programs varied in implementation status as well as numbers of industrial users contributing discharges to municipal waste streams.

Narragansett Bay Commission

The Narragansett Bay Commission serves the cities of Providence, North Providence, Johnston, and parts of Cranston and Lincoln, with a combined population of 200,000 and approximately 6,000 commercial and industrial users (Narragansett Bay Comm. 1990). It had 198 industrial user permits active from October 1989 to September 1990. The commission's Field's Point POTW, with a design capacity of 64 million gallons a day (mgd), is the largest wastewater treatment facility in Rhode Island. In 1990, EPA recognized the commission's Industrial Pretreatment Program as the best in the country for the category of large treatment plants (Narragansett Bay Comm. 1990).

The commission applied Federal categorical discharge standards to electroplaters and metal finishers that were valid prior to September 1987, when more stringent local limits took effect for essentially all industrial users. Six of the 10 local limits are equivalent to the Federal categorical standards.

The Narragansett Bay Commission uses a wide range of enforcement actions to bring industrial users into compliance, including phone calls, notices of failure to meet standards and submit monitoring reports, letters and notices of deficiency, increases in frequency of self-monitoring, meetings with users, notices of violation and public hearings, immediate orders to cease discharge, and publication of industrial users' names.

From October 1989 to September 1990, the commission made hundreds of enforcement phone calls, issued 619 notices of failure to meet standards, 428 notices of failure to submit monitoring reports, and 115 letters of deficiency (Narragansett Bay Comm. 1990). In addition, 20 users were required to increase self-monitoring, 26 notices of deficiency were issued, and 45 significant violators were listed in the *Providence Journal* on October 7, 1990. Sixteen notices of violation resulted in fines of $140,832. As of the commission's latest annual report, $82,293 had been collected (Narragansett Bay Comm. 1990).

A summary of the annual publication of "significant non-compliance" (as defined in EPA's 1986 regulations) by industrial users from 1986 to 1990 is outlined in Table 4. The total number of industries—including industrial users in addition to metals-related industries—in significant noncompliance varied greatly. Importantly, substantial numbers in noncompliance were repeaters and a significant proportion were long-term repeat offenders. In 1987, 1989, and 1990, the majority of industrial users listed as in significant noncompliance had been similarly cited during at least one prior year (over the period 1986 to 1990). In 1990, 18 of the 45 industrial users listed in significance noncompliance had been similarly cited in at least two years since 1986, nine in at least three years, and three had been cited for four years.

From 1981 to 1989, total annual metals influent to the Narragansett Bay Commission's Field's Point POTW decreased from 954,099 to 144,961 pounds

Table 4.—Summary of industrial users (IUs) published as in significant noncompliance (SNC) with the Narragansett Bay Commission's pretreatment program regulations (data: Narragansett Bay Comm. 1986, 1987, 1988, 1989, 1990).

YEAR	TOTAL IN SNC	CITED IN PREVIOUS YR.	CITED IN ≥1 PREVIOUS YR.	NUMBER OF IUs CITED IN ≥2 PREVIOUS YR.	CITED IN ≥3 PREVIOUS YR.	CITED IN ≥4 PREVIOUS YR.
1986	53	—	—	—	—	—
1987	37	23 (62%)	—	—	—	—
1988	72	20 (28%)	30 (42%)	—	—	—
1989	53	23 (43%)	28 (53%)	13 (25%)	4 (8%)	—
1990	45	19 (42%)	29 (64%)	18 (40%)	9 (20%)	3 (7%)

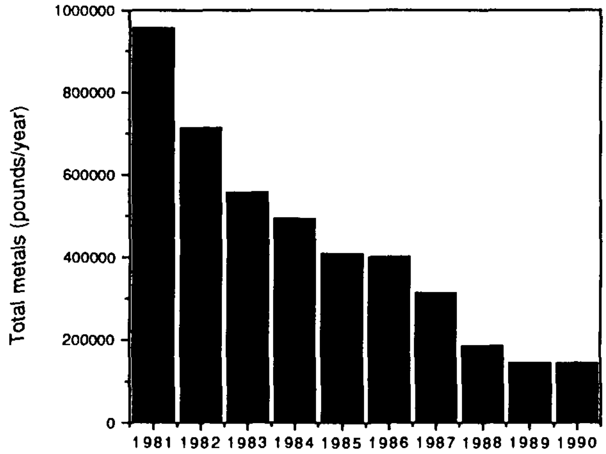

Figure 1.—Total metals loadings (pounds/year) influent to the Narragansett Bay Commission's Field's Point POTW (data: Narragansett Bay Comm. 1990).

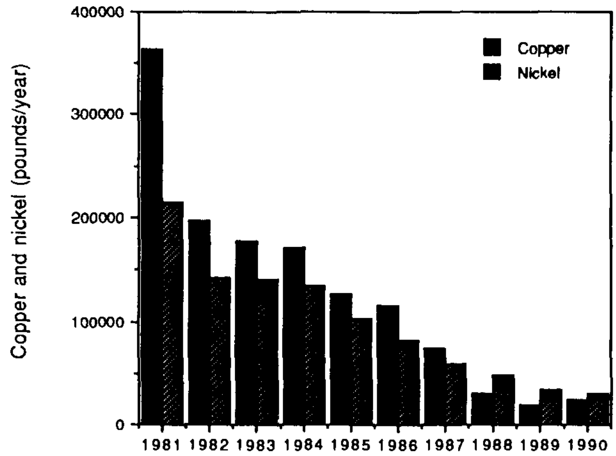

Figure 2. —Copper and nickel loadings (pounds/year) influent to the Narragansett Bay Commission's Field's Point POTW (data: Narragansett Bay Comm. 1990).

(Fig. 1). Copper decreased from 363,670 to 24,146 pounds, while nickel decreased from 214,734 to 30,887 pounds (Fig. 2), in large part as a result of pretreatment activities. However, loadings decreases resulting from industry closures and process reductions were not quantified.

Blackstone Valley District Commission

The Blackstone Valley District Commission serves the cities of East Providence, Central Falls, and Pawtucket, and the towns of Cumberland, Lincoln, and part of Smithfield, with a combined population of 100,000. The commission's Bucklin Point Sewage Treatment Plant is the second largest in the State.

In early 1990, the commission had approximately 77 significant industrial users permitted through its Industrial Pretreatment Program (Blackstone Valley Dist. Comm. 1990). Sixteen of 51 categorical industrial users were in significant noncompliance during December 1989 to June 1990. Over the same period, the commission issued 25 notices of violation and three administrative orders that resulted in fines totalling $36,000 being assessed (Blackstone Valley Dist. Comm. 1990).

East Providence

East Providence received approval for its pretreatment program in September 1983. The East Providence POTW provides secondary treatment for a design capacity of 10.5 mgd. The POTW, which serves two-thirds of the city and part of the town of Barrington (Volkay-Hilditch, 1989), has received an EPA award for medium-sized POTWs. Industrial flow comprises approximately 10 percent of the total flow to the POTW (Volkay-Hilditch, 1989); since storm sewers are separate, there is little urban runoff to the POTW. During 1984 through 1988 (the period studied by Volkay-Hilditch), the primary industrial users were metals finishers and electroplaters.

Implementation of East Providence's industrial pretreatment program was analyzed by Volkay-Hilditch (1989) and Sutinen and Lee (1990). Sutinen and Lee (1990) reported industrial users' significant noncompliance in the East Providence industrial pretreatment program to be generally below 20 percent—after an initially higher period when the industries were coming into compliance with new metal finisher local limits (Volkay-Hilditch, 1989). Metals loadings influent to the East Providence POTW are illustrated in Figure 3. Although total loadings have not declined from Volkay-Hilditch's data for 1984 to 1988, loadings of most individual metals were lower (as for copper, Fig. 4). However, nickel loadings have increased over 1984 to 1988 (Fig. 4).

Noncompliance Patterns

Sutinen and Lee (1990) reviewed the patterns exhibited by industrial users in noncompliance for the Narragansett Bay and Blackstone Valley District commissions' and East Providence's pretreatment programs from June 1985 through June 1988. During the study period, significant noncompliance (SNC) rates for the three control authorities varied widely. The Narragansett Bay's SNC rate generally ranged between 30 percent and 40 percent of industrial users; Blackstone Valley's rate swung from a high of 100 percent to near 20 percent in 1988; the East Providence SNC rate was generally lower than 20 percent (Sutinen and Lee, 1990). Similar patterns (comparatively) were present among the three control authorities for patterns of simple noncompliance (Sutinen and Lee, 1990). It should be noted

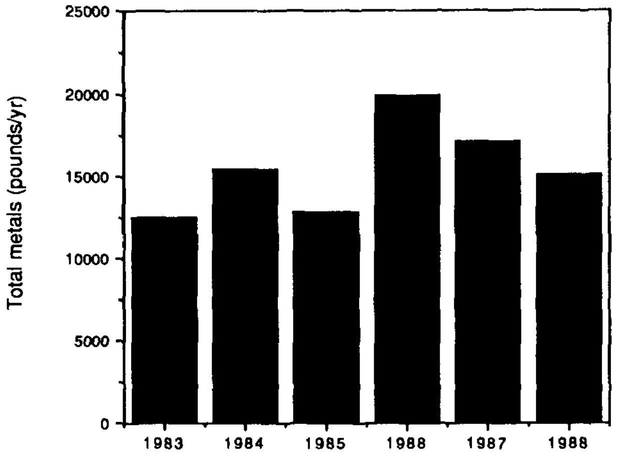

Figure 3.—Total metals loadings (pounds/year) influent to city of East Providence POTW (data: Volkay-Hilditch, 1989).

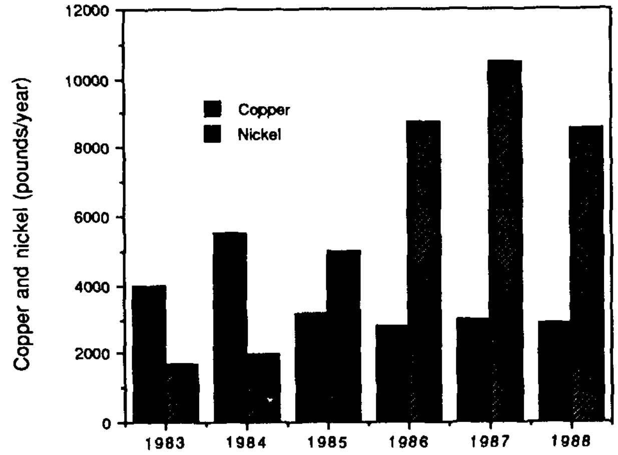

Figure 4.—Copper and nickel loadings (pounds/year) influent to city of East Providence POTW (data: Volkay-Hilditch, 1989).

that local pretreatment discharge limits differ among the industrial users (see Table 2).

Compliance Styles

Sutinen and Lee (1990) also studies compliance styles for the industrial users regulated by the three study control authorities. Over the study period, only 46 percent of Narragansett Bay's industrial users regularly complied or improved their compliance; only 30 percent of Blackstone Valley's; but nearly 100 percent of East Providence's industrial users (Sutinen and Lee, 1990). East Providence's industrial pretreatment program differed primarily in the lower number of regulated industrial users and frequency of on-site visits and audits by that control authority (Sutinen and Lee, 1990).

Metal Loadings to Upper Narragansett Bay

Much of the Providence River and Upper Narragansett Bay exceeds EPA's *Gold Book* criteria for ambient copper and nickel (Metcalf and Eddy, 1990). Estimated current total and individual metals loads to this area are enumerated in Table 5, with emphasis upon POTW contributions to total upper bay loadings. These are upper limit estimates compiled by Metcalf and Eddy (1990) by using data from a wide variety of studies conducted in the Narragansett Bay watershed as well as POTW and regulatory agency monitoring data. The bulk of current total metals loadings to the bay (58 percent) arises from POTWs, with the Field's Point facility accounting for 84 percent of all POTW contributions (48 percent of total loadings). Copper and nickel loadings show similar allocation patterns to total metal loadings (Metcalf and Eddy, 1990).

Several scenarios that affect metals loadings to Upper Narragansett Bay are shown in Table 6. The three projections all include increased loadings from projected population and industrial growth for Rhode Island (Metcalf and Eddy, 1990): loadings in 2010 with no future abatement actions; loadings in 2010 with all State POTWs having advanced secondary treatment; and loadings in 2010 with all Rhode

Table 5.—Current toxic loadings (pounds/year, partial upper limit estimates) to Upper Narragansett Bay (adapted from Metcalf and Eddy, 1990).

POTWs	Cd	Cu	Cr	Pb	Ni	Zn	TOTAL
NBC*	3,226	58,000	11,440	12,930	72,290	119,100	276,986
East Providence	82	661	218	831	1,543	882	4,217
Woonsocket	135	2,662	732	813	1,003	2,358	7,703
BVDC**	615	4,986	3,086	1,420	8,606	8,598	27,311
Cranston	33	1,969	706	892	2,117	2,043	7,760
Warwick	12	438	219	164	2,466	899	4,198
W. Warwick	66	658	190	234	351	892	2,391
Total POTWs	4,169	69,374	16,591	17,284	88,376	134,772	330,566
*Total to Providence River/ Upper Narragansett Bay****	7,050	89,340	21,030	28,340	140,300	285,100	571,160

*Narragansett Bay Commission
**Blackstone Valley District Commission
***Inputs are presented here for individual POTWs, totals for Providence River, Upper Narragansett Bay include river, combined sewer overflow, bypass, atmospheric, and runoff sources
(Cd = cadmium, Cu = copper, Cr = chromium, Pb = lead, Ni = nickel, Zn = zinc)

Table 6.—Future (2010) toxic loadings (pounds/year, partial upper limit estimates) to Upper Narragansett Bay from POTWs with various abatement procedures (adapted from Metcalf and Eddy, 1990).

SOURCES	Cd	Cu	Cr	Pb	Ni	Zn	TOTAL
POTWs							
Loadings in 1990	4,169	69,374	16,591	17,284	88,376	134,772	330,566
Loadings in 2010; no action	4,431	74,023	17,783	18,508	96,460	143,645	354,850
Loadings in 2010; advanced secondary treatment	3,663	56,605	10,528	10,359	89,658	95,815	266,628
Loadings in 2010; enhanced pretreatment	1,764	29,408	7,020	7,288	38,562	57,206	141,248
*Total Providence River/Upper Narragansett Bay**							
Loadings in 1990	7,050	89,340	21,030	28,340	140,300	285,100	571,160
Loadings in 2010; no action	7,494	94,940	22,780	30,300	150,500	301,300	607,314
Loadings in 2010; advanced secondary treatment	6,529	76,830	14,600	19,980	143,600	252,300	513,839
Loadings in 2010; enhanced pretreatment	4,374	48,750	10,700	16,420	91,690	213,400	385,334

*Inputs are presented for individual POTWs, total for Providence River, Upper Narragansett Bay include river, combined sewer overflows, bypass atmospheric and runoff sources
(Cd = cadmium, Cu = copper; Cr = chromium, Pb = lead, Ni = nickel, Zn = zinc)

Island's control authorities having a 60 percent reduction in industrial metals loadings. The projection based upon significant reductions in industrial metals loadings (the trend toward "zero discharge") offers a 43 percent greater reduction in toxic metals released to the bay than the effects of advanced secondary treatment at all POTWs (advanced secondary treatment is not directed at toxic metals reductions).

Significantly, proposed combined sewer overflow abatement strategies and proposed stormwater regulations will not result in a significant decrease in metals loadings to Upper Narragansett Bay compared to enhancements in industrial pretreatment programs (Metcalf and Eddy, 1990). Note that, within the scope of the current report, projections of loadings decreases cannot be quantitatively associated with decreases in ambient receiving water concentrations (that is, potential achievement of ambient standards).

Rhode Island's Assistance Programs

The primary means to reduce Upper Bay metals concentrations are increased emphasis on source reduction and enhanced industrial pretreatment to further reduce toxic loadings. Programs to effect these changes must include more aggressive enforcement of existing standards as well as enhanced education and transfer of technology. Rhode Island has taken significant steps to provide industrial users assistance in waste reduction.

Education, research, and technology assistance are critical components to support efforts by industrial users and control authorities to reduce toxics. The Rhode Island Waste Reduction, Recycling, and Treatment Research and Demonstration Act, enacted in 1986, promotes research, development, and demonstration of waste reduction and recycling technologies. The State DEM's Office of Environmental Coordination established the Hazardous Waste Reduction Section in October 1987 to assist industries in their waste reduction efforts.

In November 1988, the Narragansett Bay Project established the Hazardous Waste Reduction Project to assist DEM in developing its technical assistance program and to provide information on waste reduction. Three major foci of the project are:

- Transfer of information on waste reduction technologies to industry;
- Establishment of industry employee "quality circles" to identify in-house improvements to foster waste reduction; and
- Industrial waste reduction assessments by State personnel.

In 1990, following a series of discussions convened by the Narragansett Bay Project between State and local officials and industry representatives, the Rhode Island Council on Pollution Prevention was established to provide advice on legislative, regulatory, technological, and economic incentives for reducing sources.

Conclusion

A series of educational and regulatory recommendations have been suggested to further enhance toxic loadings reductions from industrial users in the bay watershed. Several of the following suggestions are adapted from studies by Brubaker (1986), Brubaker and Byrne (1989), the General Accounting Office (1989), and unpublished conclusions of the Narragansett Bay Project-sponsored metals industry roundtables:

1. Greater enforcement is needed by the control authority, State, and EPA of industrial users (and control authorities). For all agencies involved, this will require a higher level of funding to support these programs.

2. Inspection and enforcement activities to minimize cross-media waste transfer (to least expensive medium) must be established. While minimizing toxic releases to receiving waters is an important goal, it should not be accomplished through the transfer of toxic materials to other media (air or solid waste).

3. Basin-wide uniform pretreatment limits (minimum technology-based standards) should be adopted.

4. More extensive, statistically significant monitoring of industrial user effluents, POTW influents and effluents, and receiving waters is required. These enhanced monitoring requirements must be part of Rhode Island's pollutant discharge elimination system permits to POTWs. These data are critical to better assessing the effectiveness of individual pretreatment programs.

5. Requirements for better reporting protocols (internal materials audits) should be established for industrial users.

6. More emphasis should be placed upon economic incentives (fines as well as grants and loans) to encourage greater industrial user compliance. Two approaches (not exclusive) are possible. First, fines for every noncompliance action; second, substantial monetary penalties (swiftly assessed) for significant noncompliers.

7. Technical assistance must be provided to industrial users and control authorities. Adequate training of personnel involved at all stages of pretreatment is essential: certification of pretreatment operators and training of State, local, and industry personnel.

8. Aggressive pretreatment and source reduction programs are critical to meet water quality criteria for toxic metals (advanced treatment at POTWs alone will not be adequate). Pretreatment programs should encourage waste minimization and pollution prevention.

9. Cost of water should be increased to encourage conservation.

10. Techniques to substitute for chemicals that are of greatest concern (copper, nickel) should be encouraged.

11. Research and development of improved manufacturing processes must be supported.

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What Makes Coastal Standards Effective

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Introduction

The decisions and actions required to develop and implement standards to protect and enhance water quality effectively are theoretically similar for all waterbodies. Coastal waters, for example, should be of sufficient quality to meet the uses intended by people residing nearby and wildlife living in them. However, the geopolitical and geophysical complexity of coastal waters, especially bays and estuaries, sets them apart.

The historical importance of maritime commerce has concentrated populations near bay ports. The quality of these waters may be inadequate to support all the intended uses because of their current and historical functions. For instance, San Francisco Bay, the largest estuary on the West Coast, serves the competing needs of the fourth largest metropolitan area in the United States. Uses of this estuary include transportation and shipping, recreation, dilution of treated industrial and municipal wastewater, and habitat for both resident and migratory organisms.

Maintenance or enhancement of water quality to support these beneficial uses is further complicated by the varied geophysical character of bays and estuaries. The San Francisco Bay-Delta form an estuary that encompasses approximately 1,600 square miles and drains over 40 percent of the State's fresh waters. The waters of this estuary vary in salinity from fresh to marine and fluctuate diurnally as well as seasonally. The estuary includes marine, estuarine, and freshwater habitats with populations of resident and migratory biological organisms that vary seasonally.

Many elements influence standards' effectiveness in protecting and enhancing coastal water quality. For convenience, these elements have been grouped into three general categories of decision-making:

- Technical,
- Management, and
- Policy.

The role each decision category plays in the coast-al water quality standard-setting process is described in the following sections.

Technical Decisions

The upfront technical decisions for monitoring and evaluating water quality should provide the scientific basis for narrative or numeric standard values; however, the majority of these decisions are based on inadequate data.

Designation of Beneficial Uses

The initial and fundamental step in the process is selection of appropriate beneficial uses for a given waterbody. Frequently, the uses that are designated are more reflective of unrealistic desires than of pragmatic assessments of attainable uses, given the physical–chemical and demographic character of a specific coastal waterbody. Often, there are insufficient data to determine the functional potential of a waterbody, the factors that may impede it from reaching its potential, and the cost-benefits to achieving that potential.

In evaluating coastal ecosystem monitoring, the National Research Council (1990) concluded that most of the programs "fail to provide the information needed to understand the condition of the marine environment or to assess the effects of human activity on it." Inappropriate use designations may result in the development of overly protective criteria and the adoption of unnecessarily stringent water quality standards.

Derivation of Criteria

Water quality criteria represent the best scientific knowledge of pollutant exposure as related to the magnitude and type of effects predicted to impact aquatic biota and human health. Presently, these predictions are based almost exclusively on laboratory toxicity tests that use single chemicals and whose ability to predict effects in complex environmental conditions is considered controversial. Compared to freshwater chemical criteria, standards for saltwater have been derived from substantially fewer test effects using a more limited number of marine and estuarine species.

Development of Compliance Measures

Procedures to conduct chemical analyses and whole effluent toxicity (WET) tests are an integral part of water quality standards because these procedures determine compliance with the discharge limitations derived from these standards. The applicability, precision, and use of chronic and critical lifestage WET tests are controversial. Protocols recommended by the U.S. Environmental Protection Agency (EPA) for measuring responses of saltwater organisms (U.S. Environ. Prot. Agency, 1988) have not been available as long as equivalent toxicity tests for freshwater species nor have they been evaluated as thoroughly.

It is also controversial to judge unacceptable toxicity by the results of chronic toxicity tests. EPA's procedures for determining the no-observable-effect concentration assume that statistical and biological significance are equal. However, various details in test conduct and performance can so affect the calculation of a concentration that it will not reflect an effluent's inherent toxicity. For example, the test dilution series selected and the response variability of control treatments can combine to result in a statistical difference that is substantially lower than any relevant biological measure. Permit violations could, therefore, be determined by using inadequately assessed WET testing and evaluation methods.

Management Decisions

The technical decision process used to develop coastal water quality standards continues to influence their application, implementation, and enforcement. Practical considerations, however, become increasingly emphasized in these efforts to control water quality to the standards' scientifically defensible levels.

Application of Standards

The complex character of bays and estuaries greatly complicates application of coastal water quality standards. Where and how to apply current chemical water quality criteria and WET biomonitoring methods for such waterbodies are complex questions. Even defining what comprises "coastal" waters and delimiting their boundaries is not a simple matter. Congress had great difficulty establishing where coastal standards would be applied in its coastal pollution bill, H.R. 2647.

How standards will be applied is more perplexing than deciding where because of spatial and temporal variability in the physical and chemical character of bays and estuaries. Chemical criteria exist for fresh and marine waterbodies but not for waters of intermediate salinity.

Biomonitoring protocols were developed for organisms that survive within a limited salinity range. As a result, available chemical criteria and WET biomonitoring methods are relevant to a small percentage of conditions that occur in these waterbodies at any one time, and this relevancy also changes seasonally.

Spatial and temporal changes in the physical and chemical character of bays and estuaries affect the biological and ecological structure. These changes must be considered when applying standards to coastal waters. Water quality standards must be appropriate for the particular physical and chemical character of each waterbody segment and the beneficial uses each can support. In addition, these standards must change to be consistent with periodic alterations that occur. Before regulatory agencies can apply standards to waters of intermediate salinity, they must select (in a scientifically defensible manner) either available freshwater or saltwater criteria and biomonitoring species or develop suitable alternatives.

Implementation of Standards

An important part of the implementation process is the decision to adopt either numeric or narrative standards. For point source dischargers, standards are generally implemented as limitations in wastewater discharge permits. The selection of specific analytical methods and quantification limits, as well as the application of such concepts as mixing zone dilution, strongly influence how water quality standards will be translated into permit limits.

All such implementation decisions must reflect best professional judgment that balances the need for water quality protection with an objective assessment of the scientific merit of available control programs. Toxicity standards are a good example. Many States (including California) have adopted a numeric toxicity standard for coastal waters. A numeric standard was not required, and the decision to adopt one may be inappropriate given the technical inadequacy of available control programs. This is especially true for chronic toxicity standards, which rely on underevaluated WET tests of controversial precision and applicability to measure compliance with permit limits.

There is a fundamental and serious inconsistency between the implementation of toxicity and chemical standards. Only those chemical concentrations measured above a minimum quantifiable level (for example, the practical quantitation level) must be given as values in discharge monitoring reports. The minimum quantifiable level establishes a level of certainty for the measured value. The certainty or confidence in that value is determined by the calculated precision of the analytical method. There is no minimum quantifiable level applied to WET test results, although EPA (1990) asserts that "in toxicity tests, variability is measured close to the limit of detection because the endpoint of the test is already at the lower end of the biological method detection range." Reporting uncensored WET test results ignores the considerable variability of this measurement tool and increases the potential for unwarranted permit limit exceedances.

Enforcement of Standards

Enforcement should emphasize practical management decisions that recognize and integrate the uncertainties of technical decisions made in the adoption and implementation process. Toxicity limit exceedances exemplify the need for such decisionmaking.

The preamble of EPA's Surface Water Toxics Control Program final rule states: "Regardless of how numeric limitations for whole effluent toxicity are expressed, any single violation of an effluent limit is a violation of the NPDES permit and is subject to the full range of State and Federal enforcement actions" (Fed. Register, 1989).

This statement is of special concern to permitted dischargers given the disagreement over the ability of a single WET test to predict adverse environmental impacts in coastal waterbodies. This disagreement includes the controversy over the applicability and precision of available WET tests for saltwater organisms as well as how biological significance is determined from WET test results and toxicity standards are translated into permit limits.

Despite EPA's endorsement of regulatory discretion in enforcement actions, the potential for substantial civil and criminal liability, whether initiated by regulatory agencies or other parties is of great concern. There has been an increase in natural resource damage suits, and this trend will continue as an expanding number of Federal agencies (including the National Oceanic and Atmospheric Administration) focus their attention on bays, harbors, and estuaries.

Additionally, dischargers will be subject to citizen suits regardless of the regulatory agency's discretion in enforcing toxicity limit violations. Increasingly, environmental groups are litigating against Water Quality Act violations and attempting to limit the discretionary power of regulatory agencies.

In 1990, the Minneapolis-based Project Environment Foundation alleged that the Minnesota Pollution Control Agency failed to enforce the majority of large industry permit violations within the State. Its recommendations would limit the MPCA's enforcement discretion by establishing a system of standard responses to violations and allowing penalties to be assessed without court action or negotiation of stipulation agreements (Bur. Natl. Affairs, 1990).

The substantial liability associated with permit violations underscores the need for appropriate technical and management decisions in adopting and implementing water quality standards. The physical and biological complexity of coastal waters makes such decisions difficult.

Policy Decisions

Policy decisions direct the overall standards setting process rather than any individual part. Political and social considerations influence the decision of how time, effort, and money will be apportioned to protect and enhance coastal water quality. The policy decisions that set environmental priorities, select control programs, and solve program problems should be directed toward achieving realistic societal goals for the environment. These decisions also should reflect the experience gained from previous standard setting processes.

Too often, policy decisions reflect insufficiently informed choices made by the public and Congress. In its review of environmental problems, EPA's Science Advisory Board (SAB) concluded that "since public concerns tend to drive national legislation, Federal environmental laws are more reflective of public perceptions of risk than of scientific understanding of risk" (Sci. Advis. Board, 1990).

The board also recommended in its review that environmental policy be guided by a standard, systematic assessment of environmental risk that establishes priorities on the basis of "opportunities for the greatest risk reduction." Improving public understanding of environmental risk is emphasized in this relative risk reduction strategy. A standard approach to environmental risk will also improve the public's ability to compare risks and disparate environmental problems and make a more informed selection of policy alternatives from a common basis. Changing the traditional approach to solving environmental problems with SAB's relative risk reduction strategy should help improve policy decisions and make environmental control programs more efficient.

The experience gained from the present standard-setting process is equally important in guiding future efforts to protect and enhance environmental quality. It is especially appropriate on the silver anniversary of water quality standards to use the successes and failures of that process to alter future policy decisions.

The sobering fact is that, after 20 years, less than a third of the States have adopted approved water quality standards. This delay is attributable, in part, to the standards-setting process. To properly develop water quality standards, considerable time and effort are needed to determine the beneficial uses of a waterbody, establish appropriate water quality levels (criteria) to achieve these beneficial uses, and develop methods that measure compliance with these criteria.

Adoption of water quality standards has also been delayed by disputes over their applicability. The considerable costs involved in complying with these standards have motivated affected parties to closely evaluate and question the technical merit and the ability of existing or proposed control programs to effectively protect and control water quality. In particular, dischargers are concerned that

- Standards are being developed from insufficient data that do not represent site characteristics,
- Chronic WET biomonitoring methods have not been adequately evaluated to use as compliance measures, and
- Increased regulation of point source discharges is not a cost-effective way to protect and control water quality.

The need for more and better data and a more comprehensive prioritization and control program are common themes in both the SAB review and discharger objections. Policy decisions should attempt to correct these problems in present and future water quality control programs.

Recommendations

Although this paper has focused on weaknesses in the decision process for setting water quality standards, these mistakes provide lessons that can improve future standard-setting approaches. Hence, the following recommendations:

- Take advantage of the technical expertise of regulated parties by making them full partners in the standards development process.

  Too often regulated parties have been cast in the role of nay sayers because their input has been solicited too late in the standards-setting process. Substantial delays in standards adoption have resulted from the need to respond to technically valid criticisms by affected parties. EPA should use the expertise and experience of these entities by involving them in the initial development of standards.

- Standardize environmental monitoring and analyses methods and quality assurance/quality control procedures for all Federal and State agencies.

  In spite of the considerable time, effort, and money allocated to data gathering, there is general consensus that monitoring data are insufficient to support many of the technical decisions made in the standards-setting process. Often the problem lies in data sets that are not comparable or are of questionable validity rather than the absence of data. Effort must be correlated between all Federal and State agencies to perform environmental monitoring and report such measures in a proscribed, standard manner.

- Protect environmental quality in a comprehensive and integrated manner.

The multimedia nature of pollution and the need to control it in a way that minimizes cross-media impacts is central to a comprehensive environmental quality protection program. Agency participation in all legislated programs (Clean Air Act and Clean Water Act) must be guided by the same goals and standard risk-setting techniques.

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Questions, Answers, and Comments

Q. *(Dave Jones, San Francisco Department of Public Works) On the Narragansett Bay issue of heavy metals, what percent of the total heavy metals floating to the POTWs were from these regulated industries, what were from small commercial businesses, and what percent was residential?*

A. I'm afraid I don't know, but I can get you the information.

C. (Dave Jones) In California, we have a situation where the industries have been controlled, but we still are not meeting the proposed water quality standards.

Q. *In New York, we've found what's happening. The industries say they are meeting pretreatment categorical regulations—the problems (especially with some metals like copper and zinc) are really coming from corroding pipes and corrosive water. So we've been advocating a stronger look at what wastewater treatment plants ought to be doing to control corrosion. Have you come to that kind of situation in the Narragansett Bay?*

A. (Clayton Penniman) That is our concern as well, particularly in this northeastern estuary with increased acidification and its effect on enhanced leaching in water systems. As well as industrial pretreatment, we have also tried to initiate domestic limitations, primarily through education, to get people to use fewer chemicals. Even though the industrial pretreatment program is in place, we still have a history of fairly substantial noncompliance, depending upon the individual control authority. So while the Narragansett Bay Commission can point to what appear to be excellent reductions over time, there still is a history of some degree of noncompliance.

Q. *Do the sewage treatment plants in that basin have effluent limits for metals?*

A. (Clayton Penniman) Yes, they do, and that's what spurred the local limits. But these are not receiving water limits, they're effluent limits.

Q. *But they do have limits written in the permits?*

A. (Clayton Penniman) Yes.

Q. *(Bob Campaigne, The Upjohn Company, Connecticut) I've been following water quality standards developments in the Northeast, and latched on to an article in the Attleboro, Massachusetts, newspaper, where the town had been apparently assigned an effluent limitation (end-of-pipe limitation) from the POTW of 7 parts per billion combined toxic metals limit. The politicians were really up in arms because they projected that the cause was not primarily industry and cutting industry off from the plant would not solve the problem. Their preliminary estimates from consultants indicated that meeting that kind of a limit would raise annual treatment costs from approximately $3.5 million to $48 million per year. I'm just wondering if these exceptionally low numbers are necessary. I'm sure that North Attleboro, Massachusetts, represents certainly less than 1 percent of the watershed, probably less than a tenth of a percent. Projecting those huge numbers—I don't believe we can sell the public about spending that kind of money. And particularly if we cannot say, yes, we really need those kinds of limits. Can you respond to that?*

A. (Clayton Penniman) The Upper Blackstone Valley District Commission is essentially going through the same process as Attleboro over its permit renewal. They're looking at potential copper effluent limits that are substantially lower, they claim, than domestic water concentrations. So I agree with you that there are potential problems down the road—financial as well as policy problems. We have not considered the nonpoint source inputs that are probably more substantial, in many cases, than some of the point source contributions.

Geographical Targeting/ Great Lakes Initiative

The Great Lakes Water Quality Initiative—*Regional Water Quality Criteria*

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Introduction

The Great Lakes Water Quality Initiative is a regional United States program directed by the U.S. Environmental Protection Agency (EPA), Region V. Begun in 1989, the Initiative's purpose is to coordinate EPA's and the eight Great Lakes States' "activities under the Clean Water Act in order to achieve the objectives of the Great Lakes Water Quality Agreement of 1978, as Amended by Protocol signed November 18, 1987, and to provide a basis for negotiating Great Lakes water quality objectives and programs with Canada" (U.S. Environ. Prot. Agency, 1989).

Situated on the border between the United States and Canada, the Great Lakes are an important natural resource. The Great Lakes basin comprises almost 20 percent of the world's fresh surface water and provides drinking water for over 40 million people. Great Lakes water quality is managed on an international, national, regional, State, and local level. Under the Initiative, regional EPA and State water quality management regulators are working to develop region-specific water quality management programs. In addition, a public participation group has been established to provide input from within the Great Lakes basin.

A program of this size, which includes three EPA regions and eight States, has tremendous potential to affect future State, national, and international Great Lakes water quality management efforts, and as a result, benefit and/or hinder the area's social and economic viability. Significant potential also exists for Initiative developments to influence other programs outside of the Great Lakes region. Therefore, care must be taken to ensure that the regional initiative proposals are consistent with international, national, and State programs and receive the same full measure of technical scrutiny and public review.

The following guidance for regional programs is derived from a year of participation in the Great Lakes Water Quality Initiative:

1. To effectively address regional issues, regional developments must build on existing local, State, national, and international programs, with strong support and active participation from all levels.
2. Like national and State programs, regional developments must be based on sound technical concepts and valid science; significant data gaps cannot be ignored. Where there are data gaps, regional initiatives can serve an important role by clearly delineating those needs and developing programs to fill them.
3. As with all regulatory programs, regional initiatives should strive to develop programs that address critical needs and can be implemented consistently and fairly throughout the region.
4. Regional initiatives must recognize, especially for a region the size of the Great Lakes, that the developments have national significance with far-ranging impacts. Therefore, regional programs must, at a minimum, provide public notice and comment opportunities that are equivalent to national and State regulatory developments.

Within these guidelines, regional initiatives can offer exciting opportunities to address water quality and other environmental issues. In recognition of these opportunities in the Great Lakes basin, a council of Great Lakes industries has been formed to educate and inform potentially affected industries so they can participate knowledgeably in the public debate on regional issues such as the Water Quality Initiative.

Developing Water Quality Criteria

As presently proposed by the Initiative Technical Work Group, water quality criteria will be developed using a two-tiered approach. For example, Great Lakes specific Tier 1 aquatic criteria will be derived using a modification of procedures described in EPA's 1985 *Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses*. A Tier 2 narrative procedure has been proposed to derive criteria on a case-by-case basis when adequate data do not exist to establish Tier 1 criteria. As proposed, criteria derived using the Tier 2 procedure will be based on significantly less data than Tier 1 criteria and will therefore have a greater degree of uncertainty.

The draft procedures for deriving Great Lakes aquatic life criteria propose to view Tier 1 criteria and criteria derived using the Tier 2 procedure as equivalent within the existing regulatory system (Grant, 1990). For example, the draft presents the use of the Tier 2 narrative procedure as follows: "The procedures can be used to derive values for interpreting concentrations of a chemical in an effluent or in ambient water. They could represent an agency's best professional judgment and **serve as the basis for a water quality-based effluent limitation"** (emphasis added).

The draft further states: "The most recent secondary criteria shall be compiled on an annual basis by Region V EPA and be available for distribution to the public."

The proposed use of the tiered approach once again raises an important question for water quality management: should national and regional water quality criteria be developed only using consistent, well-established procedures with consistent minimum data requirements?

The answer to that question must be yes. National and regional procedures must derive criteria with the high degree of confidence around them necessary to support their use in the existing regulatory system. Without a consistent approach for their development, criteria lose value and become moving targets for both the regulating agencies and the regulated community.

Therefore, the two-tiered approach poses serious problems, and is in conflict with the well-established and accepted procedures used to derive national water quality criteria. As proposed, use of the Tier 2 narrative procedures may result in significant inconsistencies throughout the basin. Over time, criteria derived using the Tier 2 narrative procedure may be considered de facto regional criteria, without ever having received appropriate public review and comment.

While the proposal mentions the need for flexibility with the Tier 2-derived criteria and the ability to deal effectively with antibacksliding, the proposed approach does not present any realistic opportunity for this flexibility. It is important to remember that water quality criteria have many more uses than simply establishing point source discharge limitations. They are used for nonpoint pollution control programs and also serve as applicable or relevant and appropriate requirements under Superfund. In the Great Lakes, these criteria are being used to identify impaired waterways and direct remedial action plans for areas of concern.

The concept behind the proposed Tier 2 narrative procedures is similar to the idea of advisories. EPA's draft guidelines for deriving ambient aquatic advisories discusses their possible uses (U.S. Environ. Prot. Agency, 1987): "Aquatic life advisory concentrations are intended to be used mostly for evaluating the aquatic toxicity of concentrations of pollutants in effluents and ambient waters, whereas water quality criteria for aquatic life provide a stronger basis for regulating concentrations of pollutants in effluents and ambient waters."

The guidelines list two intended uses for advisories. One is as a trigger for additional data review and/or collection; the second use is to help determine the need for the development of water quality criteria for selected chemicals.

EPA never intended for advisories to take the place of water quality criteria; likewise, values derived using the proposed Tier 2 narrative procedures should not be used in place of these criteria. Every effort must be made to clearly distinguish between Tier 1 criteria and guidance values developed when adequate data do not exist to establish national or regional criteria.

Where the lack of adequate data prevents the establishment of regional criteria, criteria should not be established using limited data by default. Instead, a screening approach that provides an indication of potential concern should be pursued. The proposed Tier 2 narrative procedure has potential merit as a screening technique, but it must be recognized as such. In the event that the screening evaluation indicates a potential concern, a system that encourages collection and evaluation of additional data should be used.

Additional information needs should be determined on a case-by-case basis. In some cases, collecting sufficient information to determine regional criteria may be warranted. However, under no circumstances should values derived using a screening approach be interpreted as equivalent to enforceable water quality standards.

Conclusion

EPA and the States should avoid the use of a Tier 2 narrative procedure to develop national or regional criteria. Pending development of the necessary data to properly establish a criterion, case-by-case evaluations using all information about discharges and potentially impacted waterbodies are the only reasonable and equitable ways to establish required effluent limitations.

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BARRIERS TO IMPLEMENTING WATER QUALITY STANDARDS

Barriers to Water Quality Standards: One State's Perspective

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Introduction

Water quality standards are the driving force in State water quality and water pollution control programs. Through its standards, the State communicates its water quality goals. At the same time, the State establishes the maximum allowable concentration of each substance for which a water quality standard exists. This concentration forms the basis for the allotment of manpower and resources, permits, enforcement actions, and litigation. Since standards are the keystone of these programs, they must be scientifically sound.

Too often, however, in the rush to meet public demand for water quality protection, standards are hastily and imperfectly derived. The imperfections are frequently the result of inadequate science, which can take many forms.

One form is extrapolation from research done for purposes other than standard derivation. Another is the use of flawed research—the results of acute toxicity testing that did not achieve an end point or the effects attributed to water column concentrations derived by dilution calculation instead of direct measurement. A third is the assumption that substances of similar chemical nature will induce similar systemic or carcinogenic effects. Also there is the use of "expert consensus" in the absence of hard data, such as the current U.S. Environmental Protection Agency (EPA) aquatic life criteria for iron. A fifth form is the assumption that, because a substance inhaled in air causes a severe carcinogenic reaction, the same substance in another medium (water or fish tissue, for example) will induce an effect of equal severity.

This listing is in no way exhaustive but does identify typical problems that exist with current standards. The components of the list all share a common ground: each was used because it was the best, or in some cases, the only information available.

Almost always, there was a rider on the use that promised a better standard derived from good scientific information as soon as the current need was met. This promise was made with real sincerity; however, tomorrow brought new crises and newly perceived needs for other standards and similar diversions, that, as we moved on to the next brushfire, left our best intentions behind.

Time passes quickly. Before we realize, several years have elapsed and the standard that was interim or temporary guidance because we were going to put better science behind it has taken on a life of its own. By now, that imperfect standard has been used to derive permit limits, as an endpoint in models or as a yardstick in monitoring efforts. Technicians, administrators and bureaucrats have built programs and careers around it. It is like an old friend whose weaknesses you fondly acknowledge but wouldn't change, because you are too comfortable together. Time and effort has been invested in this imperfect standard's defense, and the change envisioned as a promise in the standard's infancy has now become a threat.

Science, during that same interval, has probably moved forward. New information has emerged that addresses or highlights the imperfections in the existing standard. But instead of welcoming the new information, we react defensively, perceiving an unwelcome challenge. Federal, State, and local agencies are reluctant to consider the new information, fearing its acknowledgement as a chink in the bureaucratic armor or the first domino in a chain reaction that will somehow undermine existing programs, or be used against them.

This defensive posture is not acceptable. The American public deserves better and we as scientists and administrators do ourselves, our professions, and the public a disservice when we cling to old standards. It is the nature of bureaucracies—and that includes academia—to be resistant to change. I submit that we need to encourage and embrace the good science that engenders change.

The recent enactment of the Clean Water Act amendments requiring States to adopt numeric criteria for toxic substances will force that change. EPA criteria that were indulged as guidance (recommendations) will be challenged as State water quality standards that require expenditures of large sums of public and private monies for compliance. Just look at Maryland and Delaware, which are faced with legal challenges within the first few weeks of final adoption of their new water quality standards for toxic substances. The major arguments in both the standard adoption process and in the current court cases is the soundness of the scientific basis for these standards.

Retaining Public Confidence

To retain public confidence in the water quality standard adoption and implementation process, we must be careful to explain and maintain the distinct differences between water quality standards to protect aquatic life and those to protect human health. It is always easier to gain public support for standards to control substances that pose a risk to human health. The public responds quickly and emotionally to these types of perceived threats.

Protective aquatic life standards rarely foster the same level of public support. Because we subscribe to the need to protect aquatic life and are often frustrated in our attempts to gain public support, the temptation to use the threat of human health risk to obtain an aquatic life protection objective can be very strong. While implementing water quality standards to reduce the discharge of toxic substances is a laudable goal, we must be careful not to create or unnecessarily magnify human health risk to drive applicable standards unnecessarily low to achieve aquatic life protection goals. The public does and will eventually perceive this type of manipulation. Like the boy who cried "Wolf!" too often, we lose our credibility and our ability to convince the public that the need for certain standards is real. Our credibility becomes a barrier.

Deriving Aquatic Life Criteria

EPA's aquatic life criteria are derived from the results of toxicity testing on aquatic organisms from a predetermined number of families. The results are incorporated into an equation that is driven by the four lowest results. The equation result is divided by two as an additional safety factor, and a single numeric criterion emerges. The "number" is translated into effluent limitations, permit requirements, and enforcement actions. The application is black and white: values less than the number pass; values greater than the number fail.

The process of deriving the aquatic life criteria was first developed by EPA in 1979-80 and was revised in 1985. Although in use for nearly 10 years, the process has yet to be subjected to a vigorous peer review.

- Is this the right approach?
- Are there better methods of deriving criteria?
- Why a single numeric criterion as opposed to a criterion that provides a range of values?
- After 10 years, has science advanced to provide better alternatives?
- How do we know if we haven't asked or seriously explored another approach?

Existing heavy metal criteria were derived using acid soluble methods. Arguments rage as to whether acid-soluble, dissolved, or total recoverable is the most accurate measurement of the metal species most likely to affect the environment. The use of the criteria is further complicated by the effects of water hardness on the toxicity of the metal. EPA uses an equation to adjust the freshwater criteria, as necessary, to accommodate varying degrees of hardness in the Nation's waters. Another complicating factor is the EPA requirement that permit limits be established and compliance monitoring be performed as total recoverable metal, while the criteria are based on acid soluble metals.

This anomaly brings much grief to State regulators, particularly permit writers. EPA efforts to develop a standard method for acid soluble metal detection vacillate in importance. Attempts to translate the metal criteria into application as dissolved metals bog down in the high degree of effluent variability. The science to resolve these questions must be done, but the time frame will be lengthy. The questionable appropriateness and validity of criteria in these circumstances create a barrier to water quality standard adoption and implementation.

While we are waiting for science to catch up, I believe there is an alternative. The criteria could be modified to include another adjustment factor, just as hardness is included now. This adjustment factor would use biotoxicity testing in 100 percent effluent together with toxicity testing in the ambient receiving water to develop a receiving water: effluent effects ratio. The ratio could be used to devise a factor by which the criteria number would be divided or multiplied to obtain a permit limit.

This procedure would not be subject to the full-blown process of developing a site-specific criterion just as the hardness recalculation is not subject to the site-specific criterion process. The procedure would allow rapid resolution of the heavy metal speciation toxicity issue on a permit-by-permit basis in a short time frame. It also provides a solution more equitable to small municipal and industrial dischargers and provides some assurance that the criteria application recognizes their situation. Furthermore, it provides a measure of effect that more closely mirrors what the aquatic life sees and enables regulators to move the whole process forward expediently.

Although I recognize that there are some scientific limitations to this approach, I do not believe they are any more severe than the scientific impediments we are now experiencing. We need to explore this type of alternative.

Addressing Estuarine Criteria

Currently aquatic life criteria address freshwater and marine environments; there is no effort at the Federal level to address the estuaries, a critical environment in 25 States.

The EPA recommendation to apply the marine criteria to estuaries is inappropriate. Estuarine species data are sometimes used in marine criteria development but almost always at salinities in the 25 to 35 ppt range. Many major estuaries have important waters in the 1 to 20 ppt salinity range. These waters experience more dramatic temperature and salinity ranges than the saltwater or freshwater environments, ranges that can affect chemical toxicity.

In another presentation yesterday at this conference, a speaker noted that marine criteria are the stepchildren in the standard development process, since marine criteria are frequently based on fewer tests on fewer species and development lags behind that of freshwater criteria. I suggest that if marine criteria are step-children, estuarine criteria are "children from the other side of the blanket" to quote an old folk saying. They receive no attention and have no standing.

There are two solutions to this problem. The first solution is to develop a receiving water: an effluent efforts ratio similar to the one proposed for heavy metals. The second is to expand criteria development to include routinely fresh estuarine and marine environments.

Developing and Applying Standards

I would like to propose that we reexamine our current approach to water quality standard development. I applaud EPA's convening of a workshop to seek recommendations for the revision of national water quality criteria guidelines. However, as part of that reexamination, we need to revisit the basics. In the development of acute and chronic aquatic life criteria, we first need to subject the current EPA approach to intense, critical, peer review by a diverse group of qualified scientists.

Publication in the Federal Register with request for comment is not peer review. Frequently, State officials and scientists neither know it is happening nor have the time to respond. I would hope that the results of this workshop will be submitted to a intense peer review by a group of qualified scientists and regulators.

The peer review process should be repeated for the information used to develop each criterion. An interval, 5 or 10 years, should be established after which the entire process would be reviewed for consistency with current science. States should be encouraged, as the frontline arbitrators of water quality standards, to develop alternative approaches tailored to the State's needs, in full partnership with EPA. If the State's number is less restrictive and based on good science, accept that number. States should not be discouraged in attempts to go EPA one better. Different is not wrong; it is merely another approach to provide a solution to meet a goal or objective.

Lack of adequate science is not the only barrier to implementation of water quality standards. Scientific adequacy arguments are further complicated by the specter of antibacksliding. The current public perception is that, if an unnecessarily stringent number gets into a permit (a "bad" number), the permit writer and the discharger are stuck with that number, no matter how inadequate science subsequently demonstrates that number to be. Resistance to the development of water quality standards by the political, economic, and regulated communities could be severely reduced by clear, crisp guidance from EPA. Such guidance should detail, with examples, exactly how the antibacksliding provisions are to be applied. If this guidance shows that the regulated communities' worst fears are real (that they can get no relief from "bad numbers"), then the States working with EPA should obtain new Federal legislation to correct this problem. It was not Congress' intent to force dischargers to bear the costs of reducing pollutants below levels necessary for protection. Removal of this fear will advance the adoption of water quality standards significantly.

Variability in interpretation as to how and where water quality standards should be applied among EPA regions provides another barrier to water quality implementation. In some cases, variability extends to differences among the States in the same region. States have social and economic reasons for remaining competitive and having requirements consistent with those in other States. When a discharger has facilities in several EPA regions and can demonstrate orders of magnitude of difference in permit limits for the same basic discharge, one has to wonder about the national validity of the standard-setting process.

Conclusion

In summation, I suggest the following actions to help remove water quality standard barrier implementation:

- Welcome change based on good science.
- Acknowledge that many different approaches can bring us to the same objective in a reasonable time. Guidance is just that, a suggested approach without the weight of law or regulation.
- Avoid the temptation to use the threat of human health risk to achieve aquatic life protection objectives.
- Revisit the entire criteria development process with a peer review group of qualified experts drawn from the scientific, regulatory, industrial, and municipal sectors. Subject the product to active public discussion over several months.
- Resolve the metal speciation issue. Either do the science in a short time (less than a year) or provide a method to develop an adjustment factor that can be used for permit units without requiring the lengthy site specific criteria adoption process.
- Develop estuarine criteria or provide a method to develop an adjustment factor to the marine criteria similar to that proposed for heavy metals.
- Provide crisp, clear guidance that interprets antibacksliding in plain English so we can decide what is needed to resolve this issue. If we need to change the Clean Water Act, let's do it.
- Standardize guidance interpretation across EPA regions.

The States, not the Federal Government, are the final arbitrators of our national water quality. In their daily water quality and water pollution control activities, States man the front lines, making the decisions and standard interpretations that result in direct water quality improvement. To make the best decisions, State personnel need to draw upon standards with a strong scientific database, standards that can survive intense scientific scrutiny and litigation. Without this firm basis, a State's regulatory credibility is open to question.

Beyond Implementation: Challenges to Complying with New Water Quality-based Standards

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Introduction

The challenge for the regulatory community is to implement scientifically sound water quality standards that industrial dischargers can comply with responsibly. Regulators often consider their job complete when they publish a final Federal Register notice. Actually, their work is just beginning because it is now up to them to work with States and the discharger community to attain compliance. Implementation of water quality standards must develop into a dynamic process that addresses both scientific feasibility and cost to industrial dischargers.

Complying With Whole Effluent Aquatic Toxicity Standards

Aquatic Toxicity Standards

In 1984, the U.S. Environmental Protection Agency (EPA) implemented a program (Fed. Reg. 1984) to use bioassays to monitor water quality. Ever since, there has been considerable work to develop new sensitive aquatic toxicity bioassays as well as methods to identify sources of effluent toxicity. The majority of Chevron's refineries and chemical plants and many marketing terminals have bioassay requirements in their National Point Discharge Elimination System permits, and many of these permits require chronic bioassays.

When attempting to implement and meet toxicity requirements, industry is challenged by their diversity. Water quality philosophy and bioassay requirements differ from State to State and, in some cases, from community to community. Many States that only have a monitoring program do not set a compliance limit because of the variable and experimental nature of effluent bioassays. Others have set toxicity compliance limits, some of which are based on the level of dilution in the receiving water. In some States, if industries exceed the toxicity limit, they are issued a violation notice, while in others, there is no notice but industries are required to conduct a toxicity reduction evaluation.

These variations also extend to the choice of bioassay species. On the West Coast the trend is to use native aquatic species. In California, a discharger may run not only the approved EPA bioassays but also ones developed by that State's Fish and Game Department with species such as red abalone and the giant kelp (Calif. State Water Resour. Control Board 1990). In Alaska, a discharger may have to conduct bioassays with Pacific salmon fry. The use of local test species often requires dischargers to develop their own test protocols or rely on ones not as developed as EPA's. Nevertheless, while bioassays with native species were considered a scary proposition a couple of years ago, they are beginning to be accepted as testing laboratories gain experience and a historical database is developed.

This overall lack of consistency hinders development of general toxicity reduction strategies and necessitates the expending of substantial resources that deal with toxicity on a site-specific basis. For instance, one refinery must comply with a flow-through acute rainbow trout bioassay, while another must comply with chronic mysid shrimp and sheepshead minnow bioassays.

Obviously, the long-term goal is no toxicity with any species. But, as tests become more sensitive, achieving absolutely no toxicity will become more challenging. Because of the varied toxicity endpoints, different approaches must be taken when implementing toxicity control and reduction measures. If more uniform toxicity limits were used throughout the country, control efforts could be more directed and less diffuse.

Toxicity Reduction Evaluations

One challenge Chevron encounters with toxicity bioassays is understanding the source of toxicity and developing strategies to reduce it. The petroleum industry processes complex chemical mixtures, such as crude oil, into other complex mixtures, such as fuels and lubricant oils. We do not deal with the toxicity of one chemical but rather the aggregate toxicity of thousands of chemicals. Rarely do we find that one chemical is the predominant cause of toxicity in petroleum-polluted wastewater.

As toxicity limits are implemented and become more stringent, industries will have to better understand how to reduce toxicity in wastewater. Many facilities are faced with meeting a compliance limit for toxicity but have no specific technology to control it. Most wastewater treatment systems used at refineries were designed 20 years ago to reduce conventional pollutants such as oil and grease, phenolics, ammonia, and suspended particulates; however, they were not designed to specifically reduce toxicity. Therefore, industry has an unclear understanding of the technology to achieve this new compliance limit.

What are industry's options when it goes out of compliance with a whole effluent toxicity limit—an event it is likely to face more frequently with the advent of chronic estimator bioassays. First, industry will focus on source control and effluent treatment system management, beginning with identification of the most toxic wastewater streams, as well as the most toxic chemicals used at the facility, and take steps to reduce or better manage them. In addition, industry will optimize the efficacy of the wastewater treatment system by improving primary separation processes and enhancing biological treatment. These process changes to reduce toxicity can take several months of planning, designing, and implementation. And even then, they may not produce a level of reduced toxicity that can enable a return to compliance.

Concurrent with implementing a source control program, the facility may begin or be forced to perform a toxicity identification evaluation (TIE), following EPA guidelines (Mount and Anderson-Carnahan, 1988, 1989). This is often the worst time to perform a TIE because source control changes in the plant may be altering the effluent composition. What is toxic one week may be altogether different the next.

An even more common event occurs just when an industry begins the TIE: toxicity disappears for some inexplicable reason. Nevertheless, the facility is facing noncompliance and must work fast. If there is a lesson to be learned, it is that regulators should allow ample time in a toxicity reduction compliance schedule for dischargers to conduct evaluations logically and sequentially.

In Chevron's experience, TIEs do not seem to work as well as EPA purports. Part of the problem is that most environmental consulting firms have little TIE experience, while EPA's research labs have had lots of practice developing and performing these methods. TIEs require both biological, toxicological, and chemical expertise, and few consulting firms combine all these disciplines. While many contractors say they can perform TIEs, few have much hands-on experience and are able to successfully combine the three disciplines.

Nevertheless, industry must not discount the EPA TIE methodologies or the use of bioassays to monitor water quality. EPA's TIE guidelines present an effective scientific approach to characterizing if not identifying toxicants in effluents. And well-controlled bioassays can indeed be valid indicators of water quality. Industry's concern lies with local regulators that often do not appreciate how technically difficult, expensive, and open-ended these programs can be and the fact that they can take a considerable amount of time and even then may not provide a definitive answer. Regulators must recognize the developmental nature of these programs and not view a toxicity reduction requirement as a simple permit checklist item. More sensitivity should be shown to the discharger's situation; regulators must allow time and even should develop resources to help the discharger come into compliance.

Even after a discharger has spent thousands of dollars and several months on EPA Phase I and Phase II TIE methods, it might not have identified the toxic culprit because this procedure is analogous to finding a needle in the haystack. Unfortunately, when dealing with complex petroleum effluents a variety of needles may exist, of which any, all, or none may be toxic agents.

The lack of definitive identification can lead the discharger back again to source control, thereby continuing the toxicity reduction cycle. In these days of new, tougher toxicity limits, more research is needed over a wide range of industries to develop more effective toxicity control strategies. The road to implementation will be smoother once these strategies are better identified.

Complying With Sediment Criteria and Bioaccumulation Standards

Over the next two years, sediment quality and biological criteria will be developed by both EPA and the States. In addition, bioaccumulation data have already been used to set human health-based water quality criteria. Recently in California, bioaccumulation concerns were used to set selenium water quality criteria to protect wetland birds.

What do sediment and biological criteria and bioaccumulation have in common? Well, they are part of a trend in setting regulatory standards—not at the end of the pipe but within the receiving water. Now, a discharger must demonstrate not only that its effluent does not cause adverse impacts when it leaves the plant, but also that the discharge does not cause any cumulative impacts in the receiving water. The implementation of these criteria could have significant ramifications to both present and past dischargers.

How these beyond end-of-pipe standards will ultimately be implemented is not as clear as for comparatively straightforward effluent toxicity testing. Once effluent is introduced into the receiving water, a whole set of additional variables and a new level of complexity will determine whether there will be adverse effects and if they can be detected.

Sediment Criteria

In the case of sediments, contamination depends not only on the water quality of the discharge but also on its location and history. For instance, if a discharge site is near a deposition zone—a location where suspended material can settle and accumulate—there is a greater chance of local contamination. Contamination is also related to the past history of the discharge site as well as the past and present practices of nearby point and nonpoint dischargers. In San Francisco Bay, some metals found in sediments can be attributed to very old mining operations that occurred hundreds of miles upstream. Thus, a discharging operator can conceivably be blamed for contamination beyond its doing or outside its control.

Further ambiguities result from determining whether the sediment contamination is, in fact, causing adverse effects to resident aquatic life. This perhaps most challenging aspect of sediment criteria development is clearly stated in the adage: "just because a chemical is present does not mean it is toxic." Adverse effects observed in field benthic communities may be related to gross sediment contamination as well as a host of other co-factors, including sediment particle size and organic carbon content, salinity, and the chemical state and bioavailability of a toxicant, as well as the sensitivity of the local species.

These factors indicate a need to allow sediment criteria to be set on a site-specific basis. If not, there is a high probability of overregulation at some sites and underregulation at others. It is important to recognize, however, that site-specific criteria are not without their shortcomings. Issues that should be resolved are what is an adequate database to make a final assessment and should a criteria apply for whole region, such as an enclosed bay, or a specific "microregion," such as the site of an individual discharge.

In any case, when sediment criteria are exceeded, remediation should not be considered solely on the basis of achieving specific chemical criteria. A comprehensive environmental health risk assessment should address all the physical, chemical, and biological aspects of the contamination.

Bioaccumulation

Both EPA and some States are showing considerable interest in regulating effluents on the basis of substances present that could accumulate in organisms in the receiving water. Recently, EPA drafted a technical guidance document on evaluating bioaccumulative substances in effluents (U.S. Environ. Prot. Agency, 1989). The issue of bioaccumulation is driven not only by uncertainties about the organisms' impact on the receiving water but also by concerns for humans and wildlife who consume these organisms and therefore can accumulate chemicals to levels that ultimately could cause toxic effects. Bioaccumulation-based objectives would protect wildlife and humans from these potential long-term impacts.

Significant technical concerns about using bioaccumulation data when developing water quality criteria include the high variabilities in degree of bioaccumulation from one organism to the next. For instance, bivalves are much more limited in their ability to detoxify and excrete substances than fish; therefore, they accumulate substances to higher levels. The level of bioaccumulation in a laboratory experiment or a mussel basket field survey often depends on the study's experimental design. Factors that may affect the final data include:

- The species to be monitored,
- The duration of exposure,
- The bioavailability of substances selected to be measured, and
- The analytical levels of detection for these substances.

While good data exist for known substances that bioaccumulate (such as methyl mercury, PCBs, and most pesticides), little is known about the bioaccumulative potential of many substances found in effluents. In addition, dischargers are not sure how to interpret this data because there is no benchmark to determine what level of bioaccumulation constitutes a potential adverse impact in individual organisms. More data should be collected before imposing regulations, and consistent guidelines should be developed for conducting bioaccumulation experiments and evaluating bioaccumulation data.

Conclusion

Over the next decade, industry will face more restrictive water quality standards. These new standards will move us beyond the traditional benchmark of water quality and may require innovative technology to meet them. We must ensure that these new criteria meet the highest scientific standards and are both necessary and attainable.

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Protection of Reservation Environments in the 1990s

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Introduction

The natural environment has always been vital to the spiritual and cultural aspects of American Indian life. The quality of the reservation environment, including the lakes, streams, forest lands, and living resources within the millions of acres that comprise Indian lands, supports tribal life-styles and the economic well-being of tribal members. The natural world, in turn, provides Indians with the fish, plant, and wildlife resources that even today constitute a significant portion of their diet.

Resources such as air and ground and surface waters are not confined to the reservation boundaries. Consequently, such resources and the life they sustain are particularly susceptible to contamination from off-reservation sources. Use of waterways and associated wetland habitat affects both Indian and non-Indian users, and thus adequate protection of these resources is a common concern to both tribes and States.

Treaty rights provide one means by which Indian tribes may exercise control over reservation and off-reservation lands. Treaties give tribes Federal authority to directly and indirectly regulate reservation and off-reservation lands. Federal environmental law is an additional source of tribal regulatory authority. I will discuss several of the key Federal statutes in this presentation.

Federal Policy

Until the mid-1980s, tribal governments were not recognized as participants and had little part in developing or implementing Federal environmental regulatory programs. As a result, national environmental programs were not being implemented within Indian reservations, and the reservation environment was less protected than adjacent, non-Indian lands. As a further consequence, tribes were generally unable to participate directly in, or receive funding through, the various Federal environmental grant programs administered by the U. S. Environmental Protection Agency (EPA).

Federal Indian policy changed dramatically in 1983. On January 24, 1983, President Reagan presented his Indian Policy Statement endorsing the twin themes of tribal self-government and tribal economic self-sufficiency. In furtherance of this policy, in November 1984, EPA published its Indian policy acknowledging the primary role of tribal governments in the implementation of Federal environmental law. One year later, in November 1985, EPA adopted its Interim Strategy for the Implementation of the EPA Indian Policy, which recognized that "[f]orcing tribal governments to act through State governments that cannot exercise jurisdiction over [Indian Tribes] is not an effective way of implementing programs overall, and certainly is in opposition to the Federal Indian Policy."

Under Federal law, a trust relationship exists between the Federal Government and Indian tribal governments. This trust gives rise to the Federal Government's fiduciary duty owed to Indian tribes. The Supreme Court has construed this trust obligation as impressing a fiduciary duty upon the United States. (*United States* v. *Mitchell ["Mitchell II"];* 463 U.S. 206, 224, *Blue Legs* v. *BIA*, 867 F.2d 1094 [8th Cir. 1989]).

EPA Indian Policy and Federal Regulation

Congress has affirmed EPA's policy of working on a government-to-government basis with Indian tribes through the enactment of recent amendments to the Safe Drinking Water Act, the Clean Water Act, and the Comprehensive Environmental Response, Compensation and Liability Act (Superfund) (42 U.S.C. 300f et seq., P.L. 99-339 [1986]; 33 U.S.C. 1251 *et seq.* P.L. 100-4 [1987]; and 42 U.S.C. 9601 *et seq.* P.L. 99-499 [1986]). These amendments acknowledge the sovereign status of Indian tribes and confirm EPA's ability to treat tribes as States for the purposes of implementing environmental programs and regulating the reservation environment.

Under the Clean Water and Safe Drinking Water Acts, tribes may seek EPA water quality program delegation and primary regulatory authority or primacy for one or more of the acts' programs. Once a tribe has received state-like recognition, it will be eligible for a broad range of funding opportunities under the acts. Under Superfund, which is not a delegable program, Indian tribes have the same opportunities for program participation as States.

Tribal Authority to Regulate the Reservation Environment

Tribal power to regulate those activities that might pollute tribal resources is derived from two principal sources. One source is the tribe's proprietary rights: the tribe has all rights and powers of a property owner with respect to tribal lands. A more fundamental and pervasive source, however, is the tribe's inherent sovereignty, which includes the power to regulate the use of property over which the tribe has jurisdiction and control.

- **Tribal Proprietary Rights.** Like any property owner, tribes may control activities on the lands they own. As described by the U.S. Supreme Court in *County of Oneida* v. *Oneida Indian Nation*, 470 U.S. 226 (1984), Indian tribes retain aboriginal title to lands they have inhabited, while the discovering nations (and their successors in interest, the 13 original colonies) may have fee title "subject to the Indians' right of occupancy and use" (470 U.S. 234 [1984]).

  As a proprietor, a tribe may condition entry upon its lands on compliance with tribal law. A tribe also has the power to exclude nonmembers from Indian lands (*Merrion* v. *Jicarilla Apache Tribe*, 102 S.Ct. 894, at 901-906 [1982]). A tribe may, by contract or lease condition, require that all proposed on-reservation pollution-generating activities comply with tribal environmental regulations.

  In addition to proprietary rights on tribal lands, tribes possess aboriginal and reserved water rights. In *United States* v. *Winters*, 207 U.S. 563 (1908), the Supreme Court found that the setting aside of an Indian reservation necessarily included the implied reservation of a proprietary water right. Implied Indian water rights have also been held to exist where water was "essential to the life of the Indian people" (*Arizona* v. *California*, 373 U.S. 546, 599 [1963]).

  A necessary corollary to a tribe's reserved water right is a tribal right to water of undiminished quality. The quality of the tribe's water right must be adequate to protect the ecological system and sustain the health of the tribe's fishery and the tribal members. In this sense, there is a nexus between the power that stems from a tribe's proprietary rights and regulatory authority that is a function of tribal sovereignty.

- **Tribal Sovereignty.** In addition to its proprietary rights, a tribe's sovereignty gives rise to its governmental police powers, which may be exercised by means of civil regulatory controls. A tribe's inherent sovereign powers extend to both its members <u>and</u> its territory. As early as 1926, the Supreme Court recognized that one of the most basic incidents of sovereignty is a government's power to regulate land use to protect public health and welfare (*Village of Euclid* v. *Ambler Realty Co.*, 272 U.S. 365 [1926]).

  Some eight years later, the solicitor of the Department of the Interior asserted that "[i]n its capacity as a sovereign" a tribe "may exercise powers similar to those exercised by any state or nation in regulating the use or disposition of private property, save insofar as it is restricted by specific statutes of Congress" (Powers of Indian Tribes, I, *Opinions of the Solicitor* at 471 [1934]).

  The scope of a tribe's authority to regulate land use through zoning is analyzed in light of the current body of judge-made or common law including the recent case, *Brendale* v. *Confederated Tribes and Bands of Yakima Indian Nation et al.*, 57 U.S.L.W. 4999 (U.S. June 29, 1989). This paper addresses the exercise of tribal sovereignty through EPA-delegated environmental regulatory programs. Accordingly, the matter of tribal zoning and land use control is beyond the scope of this analysis.

- **Treaty Rights.** Although tribal governments were not created by the Constitution, Indian tribes receive prominent mention in that document. The Constitution provides that treaties entered into by the United States, including those treaties entered into with Indian tribes, are the supreme law of the land (U.S. C. art. VI, cl.)2). Thus, in addition to proprietary and sovereign rights, any analysis of tribal regulatory authority concerning environmental issues must consider the relevant treaty provisions. Essentially, "Indian treaties, executive orders and statutes preempt State laws that would otherwise apply by virtue of the States' residual jurisdiction over persons and property within their borders" (Cohen, F. S. *Handbook of Federal Indian Law* at 271 [1982]). Furthermore, "[S]tate laws are invalidated by the exercise of a substantive Constitutional power implemented by the Supremacy Clause of the Constitution."

Tribal Environmental Law

Exclusive Federal and tribal regulation of the reservation environment furthers the following policy objectives:

- Tribal participation in Federal environmental programs strengthens the infrastructure of tribal government and avoids increased assimilation.
- Tribal participation in Federal environmental programs enables Indian land use choices to be made in response to the environmental considerations and the economic priorities of people most directly affected.
- Tribal environmental programs that clearly define the on-reservation regulatory environment serve to facilitate economic development.
- Tribal participation enables tribal members to develop technical and administrative skills in environmental programs and enables tribes to implement tribal programs and interact with the outside community.
- Tribal environmental protection programs provide tribes with the means to mitigate environmental impacts associated with on-reservation economic development.

Federal and Tribal Environmental Programs

Congress affirmed EPA's policy of working on a government-to-government basis with Indian tribes through the enactment of recent amendments to the Safe Drinking Water and Clean Water Acts, Superfund and, most recently, the Oil Pollution Act of 1990 (42 U.S.C. 300f *et seq.*, P.L. 99-339 [1986]; 33 U.S.C. 1251 *et seq.*, P.L. 100-104 [1987]; 42 U.S.C. 9601 *et seq.*, P.L. 99-499 [1986]; and P.L. 101-380, 104 Stat. 484 [August 18, 1990]). These amendments acknowledge the sovereign status of Indian tribes and confirm EPA's ability to treat tribes as States for the purposes of implementing environmental programs and regulating the reservation environment.

- **The Clean Water Act.** From a water quality management perspective, the most significant statutory change took place on February 4, 1987, with the addition of section 518 to the Clean Water Act. Section 518 directs EPA to promulgate regulations specifying how the Agency will treat qualified Indian tribes as States. Under section 518, EPA in promulgating these regulations is directed to establish a mechanism to address those conflicts arising where State and tribal boundary water quality standards may differ.

  On April 11, 1989, EPA promulgated Interim Final Rules by which the Agency will determine which tribes qualify for state-like treatment under section 518 of the Clean Water Act. (54 Fed. Reg. 14534). These rules acknowledge the sovereign authority of tribes and establish a procedure whereby tribes will be treated as States. In so doing, tribes will be allowed to participate in and receive funding for several programs under the Clean Water Act to protect the reservation environment.

  To qualify for treatment as a State, an Indian tribe must meet the following four criteria:

  1. The Indian tribe must be federally recognized.

2. The tribe must have a governing body capable of carrying out substantial governmental functions.

3. The functions of the tribal government must include management and protection of water resources.

4. The Indian tribe is determined to be reasonably capable of carrying out these functions.

Section 518 of the Clean Water Act exemplifies the expanding role of tribes in protection of their water rights on and off the reservation.

More recently, EPA has published its proposed rules concerning the adoption of tribal water quality standards under the Clean Water Act (54 Fed. Reg. 39098 [September 22, 1989]). These proposed rules provide that once a tribe has qualified for treatment as a State, the tribe may develop water quality standards. Once approved by EPA, the standards will apply to activities taking place within the reservation environment under section 303 (Water Quality Standards and Implementation Plans of the Clean Water Act). Section 303 allows development of water quality standards and in-stream quality criteria to protect uses for all surface waters of the United States.

The promulgation of the tribal water quality regulations will allow tribes to fashion standards to meet the requirements of their individual reservations. Once the standards are adopted by the tribal governing body, the tribal regulations can be submitted to EPA for review and approval.

Off-reservation activities that impact on-reservation water quality must comply with the approved tribal water quality standards. Tribes with federally recognized standards are empowered by section 401 of the Clean Water Act to deny any federally permitted activity that does not comply. This process occurs through the act's section 401 certification provisions under which States and tribes may review, approve, modify, or deny any Federal permit or license.

- **The Safe Drinking Water Act.** This act was first enacted in 1974 to provide EPA with Federal authority to protect public health through the regulation of surface and subsurface drinking water. It establishes a national regulatory program to protect the quality of drinking water from sources of known contamination.

In 1986, the Safe Drinking Water Act was amended and EPA was empowered to delegate primary enforcement authority to Indian tribal governments. Tribes may now regulate public water systems and the underground injection of wastes on their reservations.

The act was the first Federal environmental law to authorize EPA's administrator to "treat Indian Tribes as States" (42 U.S.C. Section 1451 [a][1]). Regulations promulgated under the act were the first to provide Federal recognition of the state-like status of Indian tribal government (53 Fed. Reg. 37396 *et seq.* [Sept. 26, 1988]). The amendments also made grant funding and technical assistance available to Indian tribes.

On September 26, 1988, EPA promulgated a final rule allowing Indian tribes to be treated as States for purposes of administering the public water system and underground injection control programs under the Safe Drinking Water Act (53 Fed. Reg. 37396). This rule allows tribal governments to assume primary responsibility for water quality program administration or "primacy." Generally, EPA will not delegate Safe Drinking Water Act programs to States for implementation on Indian lands (See, *e.g.*, Notice of Denial, 53 Fed. Reg. 43080 [Oct. 25, 1988]).

Indian tribes must demonstrate that they qualify for state-like treatment before EPA will make funding or delegate primary enforcement authority for either program (53 Fed. Reg. at 37399; 40 CFR 142.72 and 145.52). After receiving state-like designation, the tribe will be able to apply for EPA grant funding to develop Safe Drinking Water Act programs. Finally, a tribe can receive program delegation or "primacy" under the act (53 Fed. Reg. at 37399).

The 1986 amendments to the act require substantially the same demonstration for tribal primacy as under the 1987 Clean Water Act amendments. Under the Safe Drinking Water Act, an Indian tribe applying for primacy must first demonstrate that it qualifies for state-like treatment by showing that:

- The tribe is recognized by the Secretary of the Interior;
- The tribe has a governing body capable of carrying out substantial governmental powers over a defined area;

- The tribe has jurisdiction over the program area; and
- The tribe is capable of administering the program.

EPA has published final rules for the underground injection and public water system programs (53 Fed. Reg. 37398 *et seq.*).

State-like status is generally a prerequisite to the receipt of grant funding under the 1986 Indian amendments to the act. Tribes that either choose not to or otherwise cannot demonstrate the requisite authority to administer either program are generally not eligible to receive the special tribal funding. EPA policy is to continue to treat non-primacy tribes as municipalities subject to Federal regulatory oversight under the act. This is essentially the same status tribes held prior to the 1986 Safe Drinking Water Act amendments (53 Fed. Reg. at 37397).

- **Superfund.** In the 1986 Superfund Amendments and Reauthorization Act (SARA), Congress expanded the role of Indian tribes under Superfund (Pub. Law 99-499 [Oct. 17, 1986]). Generally, the governing body of an Indian tribe is to be "afforded substantially the same treatment as a State" with respect to many provisions of Superfund (CERCLA Sec. 126[a]).

Tribes were specifically recognized to have state-like status with respect to notification of releases; consultation on remedial actions; access to information; health authorities; and roles and responsibilities under the national contingency plan and submittal of priorities for remedial action. However, this does not include the provision regarding the inclusion of at least one facility per State on the National Priorities List.

In addition, section 107(f)(1) was amended to extend liability for damages to tribal natural resources to Indian tribes as well as damages to State and Federal natural resources to those respective sovereigns.

Intergovernmental Coordination

- **Tribal Water Quality Standards.** Although approved by EPA, State or tribal water quality standards exist as a matter of State or tribal law, <u>not</u> Federal law. EPA's approval is merely an affirmation of the adequacy of the State or tribal standards and a declaration that no Federal promulgation is necessary.

Neither State water quality standards nor the underlying State water quality management program is applicable within the exterior boundaries of an Indian reservation. Where a tribe elects <u>not</u> to adopt its own tribal water quality standards, EPA has the responsibility to promulgate Federal standards to protect the reservation environment. EPA can promulgate water quality standards in Indian country as a matter of Federal rulemaking (*e.g* 53 Fed. Reg. 26968 [July 15, 1988] [proposed Water Quality Standards for the Colville Indian Reservation]).

Tribal water quality standards are designed to meet the needs of individual Indian tribes. The designated uses for on-reservation surface waters are protected through the enactment of standards that will ensure that the overall water quality will sustain the identified uses. Once a tribal program is approved by EPA and the tribe is qualified for treatment as a State, the tribe is subject to the same EPA regulatory requirements for establishing and revising water quality standards as are approved State programs.

- **Tribal and State Cooperative Agreements.** Section 518(e) of the amended Clean Water Act provides a mechanism for resolving unreasonable consequences that may result when a tribe and an adjoining State propose differing water quality standards for a common body of water. EPA is proposing to set up a mediation process for situations where State, tribal, or international standards come into conflict. If a dispute develops, the appropriate EPA regional administrator will mediate and resolve it. Attempts to resolve the dispute may include:

  - Seeking legal opinions on the parties' obligations under the Clean Water Act, including compacts or memoranda of understanding between the parties;
  - Performing studies to define existing water uses and quality;
  - Holding informal meetings or formal public hearings; or
  - Creating a special advisory group to resolve or recommend actions to resolve the dispute.

Conclusion

Protection of the reservation environment is basic to the survival of Indian people. The importance of clean water, air, and land on Indian reservations cannot be overstated. The endless cycle of life would be broken if reservation lands and waters could no longer sustain the living resource upon which Indians rely.

Pollution of the reservation environment is not only detrimental to the health and safety of tribes but to their economic survival and that of the adjacent non-Indian communities. Moreover, for tribes to meet the demands of their members for jobs, economic development, and necessary services, they must recruit on-reservation businesses. Thus, economic development and environmental protection must proceed hand-in-hand.

Now that EPA has implemented its policy to work with Indian tribes on a government-to-government basis, it is imperative that the tribes be given a fair chance to fully participate in such programs. Working together, tribes, States, and EPA can further the goals of the Federal statutes to protect the health of the people both on and off the reservation and preserve the quality of their environment.

Questions, Answers, and Comments

Q. *(Jessica Landman, Natural Resources Defense Council) My question is for Mr. Garner. You talked about the ways the different States within the Ohio River Valley have been cooperating to address the watershed problem. My question has to do with the cross-jurisdictional issues of water quality standards setting. In the Chesapeake Bay region, we've been looking at this issue, and there are obvious complications in trying to work with a group of States. What have you done systematically to have standards that cross-jurisdictionally match up and are consistent? Do you have any formal procedures or is this all done through jaw-boning? How are you achieving consistency?*

A. (Gordon Garner) ORSANCO has unique authority. It was created in 1948 by Congress, and all the States agreed to abide by the standards set by the commission. The commission does have independent enforcement authority for NPDES permits. It uses that authority very carefully and therefore has not been as involved in enforcement actions, but its staff reviews all the permits.

The commission has a regular public list that is reviewed at every meeting. If a discharger gets out of compliance, it goes on the list, and we send it a letter. If we feel the State or EPA is not responsive enough, we can launch an investigation, which gets a lot of publicity and usually has more clout than enforcement. That brings the problem to the public's attention. If you want the States to cooperate, somewhere along the line there must be some public involvement and information.

Q. *(Jessica Landman) But what about permitting and enforcing water quality standards?*

A. (Gordon Garner) The eight States agreed to basically incorporate water quality standards into commission standards. Even though standards ORSANCO adopted may differ somewhat from those set by individual States, because of the agreement, at least on Ohio main stem permits, the States agree to abide by what was adopted by ORSANCO.

Q. *(Jessica Landman) Are you saying that legal authority is what you need?*

A. (Gordon Garner) Yes, that's ideal. Some of the other river basin commissions suffer from having limitations on what they can do. Legal authority is not the only way to get things done, but it sure helps a lot.

Q. *(George Coling, Sierra Club Great Lakes Program) Another question for Mr. Garner. The increasing evidence shows air toxics as a major contaminant, particularly of the upper lakes, with 90 percent of the lead and PCBs coming from airborne deposition and myrex in fish tissue in an inland lake. I'd like you to speak in general from a regional viewpoint on how this issue comes up in the Ohio River Valley; maybe you can put this on your list of nonpoints.*

A. (Gordon Garner) The nonpoint source study on the Ohio River Basin identified atmospheric deposition as a problem. It wasn't as significant as mining and agricultural problems and probably less even than urban runoff. But it still was identified as a significant factor. Those of us involved in water quality need to keep our eye on what the air people are doing. For 10 years, they've done nothing and now it looks like that's going to change—the air program has to catch up to the water program.

Q. *Does that study indicate POTWs as a significant source of direct pesticide volatization?*

A. (Gordon Garner) No. I have a bias on this issue. We're doing some studies and modeling on our facilities and, at least at this point, we haven't found that we're a significant contributor. However, more work needs to be done.

C. (LeAnne Hamilton, Los Angeles County Sanitation) I'd like to react to some of your comments, Bill (Diamond). The first problem that you mentioned was the need to find creative alternatives to litigation. I think we need alternatives. The thing I liked the least about your remarks, Bill, was the statement that what we really need is to have a three-year cycle for triennial reviews, and then, in that period, to require the State to adopt any criteria where EPA puts out a criteria number. That's in contradiction to your first point about wanting to avoid an epidemic of litigation. At least going by California's experience, it appears that, because of the time pressure, the difficult science, and the 303(c)(2)(B) three-year deadline, they had to do a statewide standard. They weren't able to work in a lot of site-specific factors, even when places where these factors are important in certain waterbodies.

For almost all the agriculture drains, most or all of the effluent dominated streams, and perhaps most of the stormwater and point source discharges, where there's a background water concentration and a specific objective, they can't achieve it. It just appears that many of these sources will be in violation, and it seems that EPA Region IX's policy is that this is fine, we'll put everybody on a compliance schedule. I don't think EPA should just say let's make it a long schedule. If the time that's given isn't enough, and you don't know ahead what's needed where the science is still uncertain, then, at the end of that time, you go into a consent degree. So you really are talking about a lot of litigation. How do you reconcile those two things?

A. (Bill Diamond) During the Clean Water Act reauthorization that led up to the 1987 amendments, the issue of national standards was already on the table, put there by some of the people up on the Hill. By that time, the States had toxic criteria, but most had done very little and weren't open to discussing hard and difficult questions. What carried the day (in terms of avoiding national standards) was the argument that now we've done some technology, give us one more chance and we'll clean up; we'll get these things adopted in the next triennial review cycle. However, people up on the Hill reminded us that a three-year cycle was already built into the law. The fact that, four years after enactment, only 16 States are in compliance with that requirement is not convincing to those who would give us some more rope. My suggestion is to try to come up with some means (absent immediate Federal applicability) to allow the States flexibility to do site-specific tailoring. Unless we come up with some alternatives and show that they work, we will end up with what a number of States and dischargers think is an inferior way to do this program.

Q. *(LeAnne Hamilton) Does anybody else have any suggestions for alternatives to litigation, where you can still get the job done?*

A. (Mary Jo Garreis) I've got one. I think there's a presumption of distrust among us. (It's never spoken but it exists.) The States don't trust the Feds and the Feds don't trust the States. Industry doesn't trust the States or the Feds. I think we send that message at all kinds of levels. Yesterday, when Geraldine Cox (the industry person) came to talk, half the room left. That sent a message: industry has nothing to say or I already know what they're going to say. They don't want to work with us.

We're all coming to these meetings with hidden agendas. I think it's time we got the agendas out on the table and started some real consensus building. That's going to mean compromise from a lot of different people. If we can get that through forums, meetings, and talking—on a local, State, and Federal level—then a lot of this tendency to run and litigate will go away. The perception of litigation is that it's the only way to be heard. It's one thing to hear and another thing to listen.

C. (Perry Lankford, Eckenfelder Inc.) I'd just like to thank Mary Jo Garreis for having the courage to stand up and say things that a lot of people don't want to hear. That last comment is a good one. I'd like to contrast that, Mr. Diamond, with what you had to say and get you to respond to some of her issues. You want us to be bold, you want to make some decisions and live with them, you want to get past all this endless dialogue and debate over certain of these numerical issues. What we see as barriers you think we've already cleared. We still see them as barriers.

C. (Bill Diamond) Let me just address one area that I think can be an example. We've heard throughout the conference that people face uncertainties with the criteria, the metals, and the numbers in terms of what we've got on the table and how we can resolve some of those issues. We recognize that we've got some difficulties. The counterbalance that I keep hearing is that we don't ask as much, we don't get the demonstrable results of data. We hear from industries and dischargers all the time that if you put this number on us, it's going to cost billions of dollars, we'll never be able to change, and we'll have to buy equipment. We, as Federal regulators, say that's something we ought to at least be aware of even if we can't take it into consideration in certain parts of our process—and be willing to come forward with data on the impacts or costs or what's really out there.

As Federal regulators, we have to push that issue to make sure that it's not just a barrier and a hurdle to action. There's a responsibility to do good science and good jobs to back up claims on both sides. There's a tendency in the bureaucracy not to take action. It's too easy not to do anything and to study problems to death. But in forcing that action, the real issues usually come to the fore. We usually get down to the issues and then deal with them.

C. A major barrier to implementing water quality standards is resources. I think it's interesting that the speakers were told not to talk about money. I can understand that from one perspective because if we started talking about money, we'd probably spend all of our time on that and not focus on some of the substantive issues. If anything has been clear over the last few days talking about these new areas—sediment standards, wetlands, biocriteria—it's that doing these new things right is tremendously information-intensive, which means resource-intensive. I think that we need to keep an eye on how the resources can be addressed to do these things realistically if we're going to move forward.

I'm reminded again of the Christmas present analogy from the first day of the session. While we've all seen how exciting and new all of these new presents look, it has also become clear that when you look closely at each of the packages, you'll see that innocuous but terrifying phrase—some assembly required.

Environmentalist Perspective on Water Quality Standards

An Environmentalist's Perspective on Water Quality Standards

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As we look to the future, consider the lessons of the past. This Nation's effort to achieve clean water, led by the U.S. Environmental Protection Agency (EPA), has fallen far behind the goals set by Congress in the Clean Water Act: "to restore and maintain the physical and biological integrity of the Nation's waters."

Congress established a goal to eliminate discharge of pollutants into the navigable waterways by 1985 and a policy that prohibited discharge of toxic pollutants in toxic amounts. Programs for control of nonpoint sources of pollution were to be developed and implemented expeditiously. Congress' goal of water quality (wherever attainable) by July 1983 provides for the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water.

Now, in 1990, the United States is still wide of the mark. A much more aggressive program is needed as we set water quality standards for the 21st century.

Half a century ago, when I was growing up in San Francisco, it was an exciting time to be alive. The Bay Bridge had just been finished. A World's Fair was open on Treasure Island, and I had a season's pass. My favorite spot was the Du Pont exhibit — "Better Things for Better Living Through Chemistry" — also the company that displayed products such as nylon, paints, and medicines, all created from coal, air, and water. It seemed like magic! These all-knowing wizards were leading us into an untroubled future based on new technology. I myself chose a career in organic chemistry — a decision I have never regretted.

But we didn't see the whole picture, so we were careless and overconfident. The world became a dumping ground — an unintended laboratory for unplanned experiments. DDT, PCBs, and nuclear waste wreaked havoc with the environment. Contaminated sediments and shellfish, toxic dumps, pollution of water, land, and air — the result of careless ignorance — threatened human health, animal species, and whole ecosystems. Perceptions slowly changed. Du Pont's motto became "Better Things for Better Living" — no more mention of chemistry. Rachel Carson wrote *Silent Spring*, and EPA was established.

Many years ago, John Muir recognized that everything is hitched to everything else. Aldo Leopold advised us to look at all ecosystems, instead of a piecemeal approach. Barry Commoner and others suggested that "if you don't want a problem, don't put it there in the first place." However, there are important lessons to be learned from past mistakes. To protect the environment, we must:

- **Protect the health of the whole man.** Consider not just cancer but every aspect of physical and mental health—the whole quality of life—man's place in the natural world.

- **Preserve the health of the whole environment.** Consider the impact on the entire ecosystem and the need for stricter standards in uniquely sensitive areas.

The recommendations of the Scientific Advisory Board incorporate these concepts. The EPA appears to embrace them. Now is the time for commitment and action.

- **The EPA must become an aggressive advocate for protection of the environment.** Its role as regulator and mediator of inadequate standards betrays the high purposes for which the Agency was conceived.

- **Use common sense: set class standards for substances.** Thousands of chemicals pollute the waters. There is neither the time nor resources to set a standard for each, and it is impossible to completely assess with certainty the risk of even one chemical!

  Fortunately, broad principles can be applied to simplify the task:

  - Harmful substances that persist because ecosystems millions of years old can not cope with them should not be released into the environment. We have seen many examples of problems with such classes of compounds, including PCBs, chlorinated pesticides, chlorinated dioxins and furans. For these compounds, a goal of zero discharge makes sense—unless other concentrations are proven safe.

  - For other classes of compounds (phenols, for example), rational techniques, such as quantitative structure activity analysis, can be used as the basis for class standards. These criteria should be set with an margin of safety to accommodate the inevitable uncertainty in any such technique.

  - Individual compounds that present unique hazards require individual standards.

Modify Products

Meeting adequate standards will be much easier for industry and for us all if products and processes are modified whenever possible to minimize use and production of substances that are problems to dispose of and clean up: highly halogenated compounds, for example, and compounds of toxic metals such as lead and mercury. This does not imply a complete ban, but rather wise use where there is a real need. One example is chlorine bleaching of wood pulp, which produces a variety of troublesome chlorinated pollutants. Alternative processes are available that have been proven commercially viable. With knowledgeable and proper planning, producers, consumers, and the environment can all benefit. Impressive successes in pollution control have also been achieved when use of a problem compound has simply been eliminated. (Lead in gasoline and paint is a good example.)

Set Numerical Standards

Minimum numerical standards should be set at the Federal level for application throughout the Nation. It makes no sense for each State to repeat the standard-setting process, especially when States do not have access to the best expertise and resources. State efforts should be concentrated on special problems to protect unique local ecosystems. Standards appropriate for the Port of Houston are not likely to be adequate for Florida's Everglades, where traces of nutrients can eventually destroy the natural ecosystem. States must have the authority and the duty to set more stringent standards to meet unique needs for environmental protection. When more stringent standards are needed in multi-state regions (the Great Lakes, for example), the EPA should take the responsibility to establish appropriate regional standards.

In every case, the goal must be a healthy, sustainable environment—whether it be for groundwater, wetlands, rivers, coasts, estuaries, or lakes. We are paying a heavy price for carelessness and inadequate past standards. Too often laws and regulations that are on the books have been poorly enforced. Simply correcting this deficiency would be a major improvement.

Other mistakes will be made, no matter how well intended our actions. But we have learned enough to move forward with confidence on a much more aggressive program. It will take courage and dedication, but nothing less is likely to succeed.

Apply Funding Thoughtfully

Such funds as are available for monitoring and applied research should go for well-designed programs where support is linked to good assessment of usefulness and quality. Establish peer review of proposed projects, using the best people available. Limited resources are too important to waste on ill-conceived projects. The EPA should aggressively seek funding and other resources to successfully achieve its mission.

Funding and water quality control can both benefit from the aggressive use of effluent charges and permit fees based on the amount and nature of the pollutant discharged. Substantial fees (high enough to serve as a powerful incentive to avoid them) serve to stimulate the creation and implementation of more effective control technologies and less polluting practices. These fees should be used to further improve and protect water quality. In no case should it be possible to buy the right to pollute or avoid meeting water quality standards.

The Clean Water Act does not allow dilution to meet water quality standards, and rightly so. It is time to extend this ban to mixing zones and zones of initial dilution. Water quality standards and controls should also be extended to water from agricultural irrigation and storm runoff and to ports. Such major sources of water contamination are too significant to be exempt.

Take Aggressive Actions

There is a growing realization that the time has come to take more aggressive actions and to move in new directions toward:

- Attention to all waters, including coasts, wetlands, riparian areas, and groundwater;
- Attention to whole-body health in humans, animals, plants, and ecosystems; and
- Attention to pollutant loading outside the water column, such as in sediments, and from land use and nonpoint sources.

There is also much talk of more reliance on risk assessment. Over-reliance on assessments could be dangerous because they are often of such poor quality, many times little more than guesswork masquerading as science. Don't be mesmerized by meaningless numbers. Be a courageous, vigorous advocate for the environment!

1992 REVISIONS TO CLEAN WATER ACT

Questions, Answers, and Comments

Introduction: (Bill Diamond) I want to introduce Jeff Peterson, who is on the majority staff of the Senate Environment and Public Works Committee, and Gabe Rozsa, who is on the minority staff of the House Subcommittee on Water Resources. Both Jeff and Gabe were active in the 1987 Clean Water Act reauthorization. This past session, they've been heavily involved in the debates on coastal, Great Lakes, and other bills that affect the water quality standards and criteria program. Both men have been involved in the preliminary discussions on reauthorization of the Clean Water Act, which expires in 1992. Now, I'll take the moderator's prerogative and ask each of them to comment on their prognosis for the Clean Water Act Reauthorization, both in terms of timing and likely issues, and to make any other opening remarks.

C. (Jeff Peterson) We hope to have hearings sometime in the spring on Clean Water Act reauthorization and, if all goes well, bring a bill to the committee prior to the August recess or perhaps shortly thereafter, and, in the second session, be dealing with our friends on the House side about their views on some of these issues.

With regard to water quality standards, I think generally there's a feeling among members on the Senate side that the Water Quality Standards program has tremendous potential—actually unrealized potential—but at the same time, there is a lot of uneasiness and concern about the complexity and the cost of the Water Quality Standards approach. There's a feeling that we made good progress within the past 20 years working primarily with our technology-based controls for industrial and municipal sources and that clearly we need to move ahead to much more aggressively implement the standards program in the future. There is a sense of concern about complexity and cost, and some general opinion that, since we know the technology-based approach works, maybe we ought to stick with it. Some of that feeling is reflected in the effort that has been underway for many years to get the standards program up to the point where—despite difficulties with regard to setting toxic standards—it is actually in place and enforceable throughout all the States.

At the same time, there are real opportunities in the standards program that haven't been available because we've been focusing on the technology-based side of the act. These opportunities are more directly focused on sediments, on the specific characteristics of lakes and coastal waters, the opportunity to expand beyond the specific and narrow focus on chemical contamination of water and begin to more effectively address questions relating to use impairments. There's general concern that we may have difficulty achieving some of those opportunities. A lot of the discussion and debate on the next reauthorization of the Clean Water Act will likely focus on the best things that can be done, legislatively, to help EPA and the States realize the act's potential and to overcome some of the obstacles in the program. One of those issues will be whether the Federal Government should be more directive toward EPA about initiating criteria and standards efforts with regard to chemical contaminants, toxics, or questions about use impairments.

There may be an interest in exploring the general question of State designations of uses in waters—to what extent they are comparable and whether there should be more general or standard use designations. We've talked about the role of the Federal Government in backing State efforts to put enforceable standards into place. The Senate would be very reluctant to have EPA make a blanket application of standards. Clearly, translating criteria documents into enforceable standards has been a problem. States may need a more active Federal role when trying to put together a balanced program that gives them the opportunity to look at both their waters and the criteria documents. If that does not result in enforceable standards in a reasonable amount of time, then give EPA specific direction as opposed to general authority—but only when a State fails to act.

I'd like to conclude by saying that, to a certain extent, this discussion rolls back around to the first part of the Clean Water Act, with technology-based controls and effluent guidelines as the standards become more complex and address a wider range of contaminants. In questions of use impairments, the problem of writing permits obviously becomes much more difficult and complicated, even with effluent guidelines available to ease the burden of permit writing. I think there will be a ramification back into the guidelines program. There will be a need for more help in getting permits written as the standards drive us to an even tougher water quality control.

C. (Gabe Rozsa) Let me first begin by noting that on our Committee on House Public Works we've seen a number of changes in leadership that may affect how quickly we get out of the blocks and how we proceed. I don't anticipate a change in the direction of the committee overall: clean water will be an important issue. On the minority side, there is a new ranking member of the subcommittee. However, I don't think there'll be any radical departure from the very bipartisan support of programs that we've had in the House.

In terms of timing, the scenario that Jeff laid out looks very much like the one that I'll be looking at: hearings in the spring, hopefully from EPA on their recommendations, and also from State agencies and various interest groups. Markup is a little harder to predict, but the August recess is a realistic time frame. I don't envision conference discussions being resolved in the first session.

As to the specific issues, we are will be looking at how well the existing mechanisms are working. And in terms of areas of change, it's realistic to expect some discussion about a more national approach on standards; however, there's no consensus on that issue. There are a lot of members that feel that the existing process—though slow—is a good one, of allowing States to reflect the needs of their particular area in standards. The rush for national numerical standards is going to meet resistance in many areas. There will be a great deal of interest (as there was in the current Congress) in looking at regional issues such as coastal pollution and Great Lakes problems. Some of the discussion in the Coastal Pollution Bill, however, may be more national. It's one thing to talk about coastal water quality problems in terms of standards for these waters because the ecosystems are quite different in estuarine than in riparian areas. However, enforcement issues may turn into national questions. On nonpoint sources, for example, some of the thrust of the Coastal Zone Management Act reauthorization will be revisited from a national perspective.

Sediment criteria was an extremely contentious issue last time around and it continues to be so. There will be a lot of interest in prodding (for want of a better term) EPA to move ahead on sediment criteria. And, at the same time, there will be a lot of concern about the impact to those criteria. From my committee's and subcommittee's perspective, there will be a lot of concern about the impact of the dredging program. That proved to be a significant question when the Coastal Zone and Coastal Defense bills were being scheduled for the House floor, so I anticipate that it will be again.

There's a small issue out there that could get contentious: the whole question about extraterritorial effects of water quality standards. Exactly how are you going to address interstate problems where you have, as in the case of Tennessee and North Carolina, a paper mill in one jurisdiction that's discharging effluent into another jurisdiction, and the States can't agree on applicable standards? Quite frankly, I think that the focus of the Clean Water Act is going to be more on things like nonpoint sources, wetlands, and perhaps groundwater than standards. However, there's a lot of sentiment for letting EPA move ahead with implementation of the 1987 act and, in fact, the 1972 act.

Q. *(Jim McGrath, Port of Oakland) I would like a comment from both members on issues of contention about sediment standards and procedures. Some of the discussion has involved economic major barriers that hinder remediation of some of our severe sediment problems. Past approaches have been strictly regulatory. Is it appropriate to give some consideration to the idea of incentives to look for creative ways to deal with some of these methods? And, what in particular might be the role of navigational projects, keeping in mind that many of the estuaries' most serious problems are in or adjacent to navigational channels?*

A. (Gabe Rozsa) There's always an interest in looking at incentives on more of a market-based approach to solving the problem, but I'm not quite sure how you would structure incentives in this particular situation. The whole sediment question is really complicated because it involves not only the kind of standards that will affect polluting discharges that wind up creating problems in sediment but also what you do with the polluted sediment. The latter issue is really the tougher because it has such an important impact on commerce and navigation.

A. (Jeff Peterson) If there's an incentive approach that might work, we'd be happy to hear about it. We have begun to engage the question of navigation projects and their potential to play a role in sediment mediation or restoration. The Water Resources Bill just passed speaks to that in a preliminary way. I think you'll see more of that in the next reauthorization, partly as a Clean Water Act issue and perhaps as one on ocean dumping. Although we've made a lot of progress on point sources, there are impaired uses in our streams because of nonpoint source problems and habitat destruction. We need to look at and approach water resources from a watershed basis.

There's been a lot of talk about looking at the whole ecosystem. We in Ohio agree with that approach and I think stipulations that should be put in the reauthorization of the Clean Water Act must include not only development of watershed management plans but requirements for their implementation. The idea being that there'll be a lot more teeth put into regulations for nonpoint sources and habitat destruction. What are your thoughts about incorporating something like that into the reauthorization?

A. Whether we'll be able to respond with effective legislation for that issue is hard to say. Expanding the basis of the water quality standards program and beginning to assess use impairments more clearly are really essential, but the standards program won't be much of a driving force on controlling nonpoint pollution without that evolution in the standards program and dealing with nonpoint issues will remain very difficult. The underlying question is, how to put that program in place comprehensively across the country. Certainly we will be doing everything we can with the act to facilitate that process, and, at the same time, try to make sure that the States' prerogatives in this area are protected.

C. (Jeff Peterson) While there will be a lot of looking at giving EPA and the States new teeth to put into the nonpoint source process, I think that they have a lot of teeth they haven't been using. The difficulty with Federal standards is that you are dealing with agricultural activities, and any time the Federal Government wants to get in there and regulate, it can become a very political issue. We will be spending a lot of time trying to figure out exactly how best to proceed. Any suggestions from the States would be very welcome.

Q. *(Dave Jones, San Francisco Department of Public Works) What do you expect Congress will do in terms of additional requirements in the act for control of combined sewer overflows (CSOs)?*

A. (Gabe Rozsa) I just don't know. Many people out there feel that CSOs are the worst thing and have to be dealt with immediately regardless of the cost. Others seem to think that you are discharging pollutants when you have a CSO problem, but at a time when there is a lot of dilution. And while dilution may not be the solution, there's some question as to how bad the problem really is. Clearly, some of the solutions that have been suggested, such as structural mediation, are very, very expensive. And whether or not there's enough money in anybody's budget to take on that massive problem is just not clear. I think the Senate was a little more prepared to take on that issue than the House.

C. (Jeff Peterson) I would refer to the Coastal Bill that the Environment Committee reported in the last Congress where there is a proposal for addressing the combined sewer overflow problem. That was debated at some length and reflects good sensitive judgment by the Environment Committee. That may not apply to the whole Senate or the Congress as a whole, but we have a starting place. To the extent that we do see an evolution in the standards program and increased capability to deal with problems like sediment contamination, some of the concerns that we've heard may become better understood as environmental problems. So as we start to look more generally at some of these problems and begin to factor in the sediment as opposed to just the water column, I think we'll get a better appreciation of CSOs as a problem, and certainly we'll build a better consensus for addressing it down the road.

Q.*(John Maxted, State of Delaware, Department of Natural Resources) Jeff, you mentioned the need for innovative criteria that addressed the use attainment of our waters. As an environmental scientist for a State that's just beginning to develop biological criteria, I'm finding it difficult to communicate to management about the need for these criteria because of ambiguities in the Clean Water Act. The act refers "biological assessment and management techniques." Now that expression can mean a lot of things ranging from whole effluent toxicity testing to in-stream ambient monitoring of communities. To what extent does the legislation distinguish between whole effluent toxicity as a biological monitoring tool versus ambient biological monitoring as a biological monitoring tool?*

A. (Jeff Peterson) I hope we'll be able to give you some help with that. Clearly, it's going to be an issue. We are hoping that EPA will give us their current thoughts and, as we look toward reauthorization, ideas on the best way to build on the authority that's in the act now. There is some ambiguity; however, the act was intended as a starting place. We probably need to clarify and explain some of that authority as it stands in the act.

C. (Gabe Rozsa) One person's ambiguity may be another person's flexibility. There is a lot of ambiguity in the act, and it's that way for a variety of reasons. Sometimes two camps can't come to an agreement on exactly how things should come out, so they obscure the language and everybody claims victory. However, there's a lot of authority in the Clean Water Act if EPA and States want to exercise it. You guys are the experts far more than we on what works and what doesn't. Rather than going to your State and saying it's not clear whether the

Clean Water Act requires this, you should be asking, is it a good idea? Should we do it on our own? Does it make sense? Will it work? One of the great things about a program like the Clean Water Act is that you have 50 to 60 jurisdictions out there that can experiment with different solutions to problems in their areas, use that authority, and get back to us to tell us what's working.

C. One is an end-of-pipe method and the other is an out-of-pipe method. They are too vastly different to really combine into one expression.

C. It's not the first time we've had radically different concepts combined into one expression.

C. (David Cohen, State of California Water Resources Control Board) Where the Clean Water Act gets into the way of clean water, the act should be changed. The only specific proposal I've heard during the past few days where there should be change is in the antibacksliding provision. In the past, permittees have been required to maintain a minimum chlorine residual for disinfection purposes, which conflicts with the new emphasis on chlorine discharges to the oceans and inland waters as much as possible. To this day, EPA has a requirement to chlorinate offshore discharges for the minimum chlorine requirement. Do either of you feel there would be significant opposition in either the House or Senate to changing the antibacksliding provisions to make sense from a water quality standpoint? I think that's something that every interest group in this room would support.

C. (Gabe Rozsa) I'm a believer in flexibility. Many of us with the House and Senate had some concerns about the antibacksliding provisions' rigidity, but I didn't sense much willingness to be flexible the last time around. Maybe the example you've given would create some incentive to revisit that issue, but I'm not terribly optimistic about it.

C. (Jeff Peterson) Any proposal to weaken antibacksliding provisions would be very tough to get through the Senate.

Q. *Would this necessarily be a weakening of it?*

A. (Jeff Peterson) We'd certainly consider a coordination role that allows or prevents changes to be brought into the existing language; no one wants to make problems. However, the concept of antibacksliding is strongly held by the Environment Committee. There would have to be a lot of confidence that whatever we were doing to fix a particular problem would not somehow open the door to a broader weakening of the provision. Without that kind of confidence, there'd be great reluctance to mess with it.

C. People are less willing to experiment with innovative approaches to solve antibacksliding problems. Their approach is very cautious and, ultimately, has a negative impact on water quality. We should be trying different things and, if they don't work, throw them out and go to something else.

Q. *(Bob Erickson, EPA Region VIII, Denver) Most of the groups—EPA, environmental, and water use—want clean water; however, we differ somewhat on what is clean and what the costs should be. Meanwhile, State staffs are often overworked. What is your feeling about increased support for reauthorizing funding for State staffs?*

A. We have to take a hard look at funding of State programs in the reauthorization. Compelling information from both the Association of State and Interstate Water Pollution Control Administrators and EPA cites the shortfall in funding various functions that States are undertaking. Clearly, we should consider increasing the 106 funding.

A related issue is how we use new authority in the act to provide for funding (on a fee basis) of permit issuance. (Some States are using a large portion of their 106 grant to support permit issuance.) If we can find an alternative database source of funding for permit issuance, that will free up some of the 106 money for more underlying State programs like standards development. That could be critical to any effective and comprehensive evolution of the standards program in the next 10 years.

We can't give you a substantial increase in the basic resource. You have to expect the States to aggressively implement even a contaminant-specific standards program. We're looking at expanding the program in use impairments and related areas—sediment and other things. If we really want to do all that, we've got to come up with a better way to fund the program.

C. The whole issue as to how much money States will have to implement these important programs will be central in the reauthorization. In 1987, one of the things that came as a surprise to a lot of people was that, with the phaseout of the construction grant program, the set asides managing that program were also going to disappear. And while some pretty good interim steps have been taken to address the shortfall, it continues to be significant at the same time that we're imposing additional requirements on the States.

With respect to fees, Congress just acted on that in the Reconciliation Bill. We called on EPA to implement a fee program to recover $10 million; however, the perception is that there will be no State permit fee where EPA continues to run the program. In the context of the House Coastal Defense Bill, there was, at least in the Merchant Marine version, a big push to require a permit fee although there was a mechanism for States that already had a system to opt out of the process. While there is a lot of interest in moving toward a fee system, the concern is for those States that already have a functioning effective permit fee program. We don't want anything at the Federal level that is either going to compete with that system or somehow interfere with smooth operation.

C. Along somewhat related lines, I'd like to follow up on a recommendation made by the earlier speaker from the Sierra Club: it may be time to look at effluent fees in the water quality area. Clearly it's a difficult area, and once you get to any specific proposal, it tends to be somewhat blunt and therefore easy to attack. One potential starting point (for all its defects) may be the priority pollutant list or some subset.

C. (Gabe Rozsa) The problem is for fees to have a real impact on decisions about discharges. Some fees will have to be pretty steep. How will you implement a real steep fee schedule when we just went through a round of telling industry that they have to put through all these changes for the Clean Air Act—and in this shaky economic situation? A massive fee charge will be difficult.

The other question that comes up is marketability. If I pay that fee, to what extent will I be able to market my right to discharge that pollutant? We're not embracing an approach that says that you can pay for the right to pollute; rather you're paying for the cost that you're imposing on society. For a fee system to be really effective as a market incentive, it must have tradeability—which raises other philosophical questions.

C. (Jeff Peterson) This will certainly come up in the reauthorization; however, sorting out all the many questions associated with a significant effluent tax will be an uphill battle. I give working out this reauthorization less than a 50/50 chance. There may be some opportunity for something more than a simple permit fee system, but not something driven strictly to influence behavior in some way to an economic incentive. Clearly, the size of the tax involved may be somewhat overwhelming. We have a problem with long-term financing of municipal pollution controls. There may be some way to factor in an effluent charge that is greater than the cost of permit issuance if it's directed toward meeting short-term and long-standing funding as opposed to trying to go as high as you would with a tax to drive behavior.

There are some strong philosophical reservations on the Environment Committee about sanctioning discharges with a fee or a tax. How do you keep that consistent with the more long-established goals of zero discharge in the act? Is this sending conflicting signals? And there's one other practical problem to be solved that has been difficult in the past, although it may not be insurmountable: going beyond a fee-based system would require getting the support of the Finance and Ways and Means committees.

Q. *(Glenda Daniel, Lake Michigan Federation) As part of the national sediments working group of environmentalists, I certainly agree with what Gabe said earlier about dredging and disposal. Our group has some allies among Great Lakes ports that are not fully accessible because they are not dredged. I wonder if you have some thoughts on which governmental body would look at funding options for dredging and cleanup and if it would help to have disposal guidelines from EPA or anything else that would be useful to know to get better settlement management. Pollution prevention is going to be an even stronger issue. What problems do you expect with getting pollution prevention into Clean Water?*

A. (Gabe Rozsa) That's a funding question, and I don't see any easy solutions. We just saw a threefold increase in the user fees that domestic and international cargo carriers have to pay to maintain harbors around the country, so I don't envision further increases. Beyond that, if you're not charging users, your other option is taxing them directly. If we impose additional requirements, the cost of disposing dredged material is sometimes split 50-50 between Federal and State governments; in other circumstances, it's just a State or local responsibility. That leaves you with the Federal treasury as a funding option, and times are tough.

There's a lot of material on disposal guidelines from EPA and the Corps. One of the fundamental issues in that debate is where do you just draw the line and say if the material meets the criteria, you cannot dispose of it in water but you have to find someplace else, versus an approach that says, well let's take a look at what it is and how bad it is and then determine the best disposal option rather than ruling one option out entirely. It's great to say that if sediment is polluted you can't put it in the water, but you have to do something with it, and any of those options involve a certain degree of risk.

As far as pollution prevention, I agree we'll be spending a fair amount of time on that. Sediment criteria is the most interesting aspect of the debate—not so much using those criteria as a benchmark for disposal options but deriving the permit process to prevent pollution in harbors.

C. (Glenda Daniel) Enforcement is another option for industries; for instance, of municipalities that have been discharging into those areas. Northwest Indiana has fined dischargers to clean up the sediment. There are also some technologies for breaking down the contaminants in sediments that could add to the disposal possibilities.

C. (Jeff Peterson) We haven't really agreed on definitions for sediment contamination, grades of contamination, or in which types of action. We can't even agree on applying sediment standards to dredging, even the most general ones that were proposed in the Senate's Coastal Bill during the last Congress. Until we understand when sediment is contaminated and requires some action, and in what location and to what extent contamination is present, we won't know what kind of funding is needed. Asking where should we go to get funding is putting the cart before the horse. If it's within the port's ability to pay, perhaps that would be appropriate. Clearly, sedimentation will down ports across the country, which will be a major disruption of commerce.

While there is a Federal role and maybe one for existing revenues of the treasury, there also may be a role for other funding mechanisms—but we don't even know the total dollar figure yet. I'd hate to have a number materialize out of thin air, have everyone say that it's too big, and then forget about contaminated sediment. We've done just that for a long time. We must stop thinking that contaminated sediment isn't as much of an environmental problem as, for instance, a Superfund site. The people that polluted Superfund sites are paying to clean them up; that hasn't really happened with contaminated sediment. So until we can get to that point, I'd like to reserve judgment as to the costs.

C. (Gabe Rozsa) Of course, it would be a lot tougher to find industries that were responsible for contaminants being in the sediment than it is for some of the Superfund sites. With sediment, you're talking about perhaps an entire river basin as the ultimate source of contaminants. Trying to identify the potentially responsible parties could be a massive undertaking.

Q. *(Kevin Brubaker, Save the Bay, Rhode Island) Gabe, your committee will be working not only on the Clean Water Act but on the Surface Transportation Act. Can you give us any reassurance that the right hand and the left hand will be coordinated and that the Surface Transportation Act will be used as a tool for controlling nonpoint pollution as well?*

A. (Gabe Rozsa) I can assure you that the chairman and the ranking member of the full committee will try to balance those issues. These issues are both before the committee but are being handled by different subcommittees. I'll be trying to track what's going on in the surface area perhaps even more than what goes on in other legislation pending before the Hill. The surface people will also be tracking what's going in water, but more importantly, I think, Bob Roe and John Paul Hammerschmidt will be doing that.

C. (Mark Van Putten, National Wildlife Federation, Great Lakes Office) On the sediment matter, I would disagree with Gabe. In most instances, the sources are easier to find because they are stationary. It's not like barrels that were shipped all over the place.

But what has brought me to the microphone is antibacksliding. I want to counteract the impression of unanimity here that the antibacksliding section is a problem and should be changed in the upcoming reauthorization. The problem is EPA's failure to issue regulations addressing antibacksliding. A draft interim guidance document has been around for at least a year that some States are relying on; however, others don't know what to do. The real issue with antibacksliding is the uncertainty. EPA must address that, and until it does, a case cannot be made that the antibacksliding section as adopted by Congress is not working.

One issue that has produced unanimity is the additional attention needed on implementation of water quality criteria and the standards. It's ironic that Congress has spoken specifically on implementation of antibacksliding. I haven't heard much from committee staff about implementing antidegradation or a move to prohibit or limit the use of mixing zones and other dilution techniques allowed in the implementation standards by EPA's current technical support document.

C. There would be a lot of reluctance on the Senate side to change the statutory basis for antibacksliding. I'm sure that, as EPA and States continue to implement this provision, we'll begin to get a better sense of the issues and if Congress needs to clarify, expand, or maybe even narrow some of the provisions on antibacksliding. Clearly, we're looking for guidance from all the different parties as to whether that's necessary. We will want a pretty compelling, coherent case as to why a change is needed.

C. (Ed Rankin, Ohio EPA) I'm encouraged by the mention of a discharge fee for managing NPDES permits; however, the water quality issues we're dealing with now are extremely complex. You mentioned questions about the severity of combined sewer overflow problems. I think they stem from the lack of ambient monitoring data that's accompanied decisions on where we issue permits. I'd like to encourage that, if there's a discharge fee, a percentage of that fee go to ambient monitoring, biocriteria, extreme chemistry integrated and watershed-type approaches so that we know what we're getting for our money and why the permits are issued.

C. (Jeff Peterson) I think the House CDI bill did carve out a certain percentage of the fee for ambient monitoring. There's a lot of support for increased monitoring. The U.S. Geological Survey has a very active program that monitors water quality around the country, but there's no doubt that more needs to be done. Linking the fees with monitoring is certainly an idea that has been discussed and will be in the reauthorization.

C. (Ed Rankin) The treatment that we're putting on discharges will be more expensive than the money spent for monitoring. However, it's really a small amount of money in relation to the amount that the public and the economy will be spending on treatment.

C. (Jeff Peterson) As we look at how to design a fee, we'll also be questioning whether we should cover just the narrow costs of permit issuance and if a fee should realistically cover some of EPA's State base program support functions, which would include monitoring. A related question is whether we should provide authority more specifically in the act for States and EPA to include more general monitoring requirements in permit issuing. That's slightly removed from whether the upfront fee should be pumped back into an EPA and State monitoring program or whether the permit itself should simply impose a burden on the discharger to conduct specified monitoring. There are probably advantages to doing one way or another and it may be that we do both, as long as they are coordinated effectively.

Q. *(Carol Ann Barth, Alliance for the Chesapeake Bay) In recent iterations of the Farm Bill and the Coastal Zone Management and Clean Air acts, we see greater movement in the direction of water quality. Of this iteration of the Clean Water Act, what do you expect to see in terms of greater coordination and other environmental legislation or more general moves toward a focus on cross-media or life cycle pollution?*

A. (Gabe Rozsa) There is a lot of rational support for a cross-media approach. In fact, many of our problems now are the result of the pigeon-holed approach. Unfortunately, I can't be terribly optimistic that we're going to wipe the slate clean and come up with a more holistic approach to solving water quality problems. That's a factor of the way Congress works. Different committees have jurisdiction over different aspects of the environmental programs. In the Groundwater Bill that passed the House about three years ago, five committees had to come together over a nonregulatory bill to reach consensus on the language before we could take it to the floor. Trying to bridge the relationships of these various laws is going to be even more difficult than dealing with an issue that just touches on several different jurisdictional concerns.

Q. *(Carol Ann Barth) Should I take that as a "not much?"*

A. (Gabe Rozsa) Yes, I guess so.

C. (Jeff Peterson) I don't see any sweeping change with regard to finding a cross-media focus for pollution control. In this reauthorization of the Clean Water Act, we'll do what we can to assure effective coordination with related statutes. The most obvious opportunity will come with reauthorization of the Resource Conservation Recovery and the Clean Water acts. Both bills will be actively under discussion and have areas where they should be better coordinated. We will be working on trying to make this happen in one bill or the other.

Q. *(Bill Diamond) Let me put a last question to the both of you. Do you have a reaction on the need for Clean Water Act changes in fish advisories and the fish bans that have been controversial or in the area of flow standards as opposed to the traditional criteria standards?*

A. (Jeff Peterson) I'm sure we'll be looking at both those issues. I know the Agency has been exploring the flow issue and we'll be very interested to hear its suggestions. On the fish advisory issue, there's a pretty strong case that we need to clarify responsibilities and better establish the basis under which advisories are issued for fish consumption: who would do it and whether it's based on the nature and the presence of contamination in the fish product or of the waterbody from which the fish are drawn. There may be a role for advisories both on the quality of the fish itself as well as the quality of the water from which the fish is drawn. There's a lot of uncertainty and confusion and if we've got an opportunity that can result in less confusion, I'm sure we'll try to do it.

A. (Gabe Rozsa) I agree. Fish advisories, in particular, could be a very contentious issue. We will also hear more about things like uniform standards on beach closures.

Closing: (Bill Diamond) I'd like to thank both Jeff and Gabe for taking the time to come here and all the speakers and the participants for their ideas and comments over the last couple of days. I would encourage you to continue the communication with EPA and among yourselves through sessions, meetings, phone calls, or writing so we can continue this discussion.

Summary of Moderators' Reports

Panel members for most conference discussion sessions were asked specific questions by the moderator. The following is a compilation of their answers.

What does your panel think is the largest need from EPA?

- **Toxic Pollutant Criteria:** When developing State standards to control toxics, there needs to be an integrated risk-based approach that uses chemical-specific toxics control, whole effluent toxicity, and biological criteria. To accomplish this, more toxics criteria should be developed at a faster rate for high priority chemicals. The chemical form and detection limits suitable for effluent analysis should be expressed properly.

- **Sediment Management Strategy:** EPA should expedite criteria for sediments (panel's most popular choice). An interpretive framework is needed for sediment quality criteria (presumed more important than the criteria themselves). Inventory and prioritization are also considered priorities. Lastly, six organic criteria will be published in draft in August and six per year thereafter. However, there has been no Agency decision yet on standards.

- **Contaminated Sediment Assessment:** EPA should provide not only numbers but instruction on using sediment criteria rationally. Assuming not all contamination will be cleaned up, will EPA provide a decisionmaking process for sediment remediation? The Agency also should:
  - Evaluate the cost impact of criteria under its proposed implementation scheme,
  - Determine the relationship between water quality and sediment quality,
  - Prioritize problem sediments, use a risk-based approach, and develop an effective ranking scheme,
  - Develop risk–benefit analyses for developing and implementing standards (action level) from numerical criteria,
  - Clarify what it expects from States (lay down ground rules in the beginning, don't make it a guessing game), and
  - Define how numerical criteria would fit into dredged material management.

- **Wetland Quality Standards:** EPA should provide additional technical guidance (like the recent guidance on water quality standards for wetlands for the FY1993 triennium), additional EPA training programs and workshops for State personnel and others, and additional technical assistance from EPA personnel and Federal grant monies to support them.

- **Ammonia/Chlorine:** EPA should proceed toward implementing chlorine criteria and continue to encourage State adoption of ammonia criteria where needed to protect beneficial uses. The Agency should revisit chronic freshwater ammonia criteria and look at combined impacts of ammonia and chlorine. Because of impacts of pH and temperature on ammonia toxicity, better methodology is needed to determine site-specific impacts.

- **Coastal Water Quality Standards:** EPA should take the lead in coordinating activities between States in criteria (chemical and biological) use and implementation (controls and enforcement). States need EPA's help to develop and standardize new methods of assessing ecological health (such as SAV, biocriteria) and ensure consistent enforcement of controls and limits.

What is the most important action States can take to achieve program objectives?

- **Toxic Pollutant Criteria:**
  - States not in full compliance should develop water quality standards for those compounds for which there is EPA guidance.
  - States should provide EPA with a priority listing of chemicals for which criteria should be developed. It should focus on

chemicals resulting in regulatory action not on the list of 129.

- **Sediment Management Strategy:**
  - In anticipation of criteria, get together a framework.
  - Establish a bona fide program for sediments.
  - Monitor sediment and control sources.
  - Inventory and prioritize.

- **Contaminated Sediment Assessment:**
  - Acknowledge that sediment quality protection is a bona fide State objective.
  - Reprioritize monitoring activities to take sediment into account.
  - Make an effort to incorporate Federal guidance into State programs.
  - Incorporate numerical criteria promptly and efficiently into environmental protection programs.

- **Wetland Water Quality Standards:**
  - Enhance 401 certification and permitting, enforce permits that have been granted, and develop narrative water quality standards and legislation that allows vigorous enforcement of 404 permits.
  - Deny permits when necessary and protect wetlands from adverse impacts.
  - Develop additional mitigation policies that relate to these issues.

- **Ammonia/Chlorine:**
  - Continue to move toward control of chlorine discharges by adopting numeric criteria.
  - Proceed toward establishing ammonia criteria where determined necessary to meet beneficial uses. May want to look at toxicity assessments.

- **Coastal Water Quality Standards:**
  - Talk to other States with similar estuarine systems, using EPA to moderate discussions.
  - Communicate to the public on the condition of estuaries and the need for controls (both land use and point sources).

- **Barriers to Implementing Water Quality Standards:**
  - Accelerate implementation of EPA's policy on Indian tribes by the following procedures:
    - *EPA regions should consider having established goals to approve a certain number of tribal water quality management plans in each fiscal year.*
    - *States should also consider specific goals to develop "X" number of Clean Water Act cooperative agreements between tribes and States.*
    - *Both States and EPA should explore the development of model programs, using a tribe-teaching, tribe-approved approach.*
    - *EPA could consider establishing a national level periodic report on the progress of tribal programs.*
  - Keep pushing to resolve lingering issues that are making States and the regulated community reluctant to adopt standards (such as which forms of a particular metal are applicable to standards attainment) and clearly define the requirements of antibacksliding.
  - Give full consideration to techniques being explored (at EPA research labs) to expedite site-specific application of toxic criteria—particularly to the use of effluent effects (or water effects) ratios.
  - Expand the peer review process for EPA standards guidance and criteria.
  - Accelerate additional guidance. This will reduce discharger uncertainties about techniques and level of difficulty in conducting toxicity reduction and identification evaluations, especially for chronic toxicity.
  - Fully explore the implementability of sediment toxic criteria. EPA's plans to seek State input in 1991 are a good start.
  - Explore the potential for easing standards implementation by adjusting other programs that interact with standards; encouraging flexibility in enforcement requirements and compliance schedules with new toxic criteria, particularly with new forms of criteria (such as sediment and biological criteria) as they are

implemented; and further defining and incorporating the role of nonpoint source controls and watershed management approaches in achieving standards attainability.

What are the biggest obstacles to achieving program objectives?

- **Toxic Pollutant Criteria:**
  - The pace of criteria development is too slow, and implementation of criteria into permit limits differs too much among States.
  - Toxic criteria should be developed for all uses and media as well as a prioritized list of toxics that need criteria.
- **Sediment Management Strategy:**
  - Lack of recognition about importance of sediments and complexity of sediment issue; need for flexibility in application of criteria, control decisions, and so on.
  - Lack of a clear Federal legislative mandate.
- **Contaminated Sediment Assessment:**
  - Inadequate development of scientifically and technically defensible numbers.
  - Inadequate definition of bioavailable fraction of all chemicals in sediments.
  - Making sediments second priority in consideration of overall environmental quality program.
  - Industry's and permittee's perception that numerical criteria will bring overwhelming and costly environmental controls (i.e., will paralyze their ability to function).
  - Protracted lack of consensus on approaches.
- **Wetland Water Quality Standards:**
  - Our biggest obstacle is the lack of resources and personnel to do the job. Tennessee's Division of Water Pollution Control has lost two technical positions in the last five years. Its Division of Natural Resources has decreased from a staff of 10 to 6, yet will issue over 400 permits in 1991.
- **Ammonia/Chlorine:**
  - The costs associated with meeting ammonia criteria and lack of actual in-stream data on impairment to demonstrate to the public the need for these expenditures.
- **Coastal Water Quality Standards:**
  - The easy answer is money; resources at the State level to develop programs and coordinate (travel) with other States.
  - Other than money, the biggest obstacle is galvanizing public support to pay for the control that will be needed.

Water Quality Standards for the 21st Century

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