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Proceedings

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A National Conference on Watershed Management

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Foreword

By many accounts, WATERSHED '93: A National Conference on Watershed Management was a watershed event. More than 1,100 people participated on-site over the 3 days of the conference in Alexandria, Virginia. Hundreds more participated via satellite broadcast on the final day of the conference. It was the first opportunity in many years for people with diverse perspectives from a wide variety of disciplines to exchange ideas and information concerning comprehensive watershed management.

These proceedings contain the presentations and discussions that took place during the plenary sessions, including the satellite broadcast, as well as many of the papers that were presented in 30 concurrent sessions. The first part of the proceedings includes all of the plenary session papers and discussions. Part two highlights the remarks of the luncheon speaker, Michael Robinson, Director of the National Zoo. The third section contains all of the concurrent session papers that were submitted for publication, in the order in which the presentations were listed in the conference final agenda. Finally, an index of all authors is included so that you can easily locate a paper if you know the author's name.

The views expressed in the proceedings are those of the individual authors and should not be construed as endorsements, recommendations, or the official positions of any of the agencies that sponsored the conference.

Acknowledgments

Numerous people deserve credit for the success of the conference. Special thanks go to the Steering and Planning Committees and the conference coordinators. The speakers, moderators, field trip planners and presenters, room monitors, and small group discussion facilitators all spent time preparing for their portions of the program and their work is much appreciated. The satellite broadcast could not have happened without the skillful attention of Janet Poley and Cathy Bridwell of the USDA's Extension Service, and Greg Low of The Nature Conservancy deserves special mention for his role as Master of Ceremonies. Thanks also to Ken Lanfear of the U.S. Geological Survey for producing attractive and informative maps of the watersheds of the United States, including the image on the cover of these proceedings.

The conference logistics were superbly handled by Terrene Institute, and the proceedings were prepared with the expert assistance of Tetra Tech, Inc. The editing team from the U.S. Environmental Protection Agency—Paula Monroe, Anne Robertson, Joan Warren, and lead editor, Janet Pawlukiewicz—also deserve special recognition.

OFFICE OF THE VICE PRESIDENT

WASHINGTON

March 24, 1993

To the Participants of WATERSHED '93:

I commend all of you for your dedication to protecting our Nation's water resources. Great strides have been made in improving the health of the Nation's waters thanks to the efforts of many people around this country -- including many of you here today.

However, as you all know, our waters are still in danger. Today's threats such as nonpoint source pollution and habitat degradation require new and creative solutions. With its holistic approach, watershed protection provides a means by which we can address and overcome the perils facing our waters.

I realize that for many, watershed management represents a new way of thinking. This new approach will require major changes in your current methods of operation. Adopting this watershed protection approach will not always be easy and there will be obstacles to overcome. Rest assured that you will not be facing this challenge alone. As part of our economic stimulus package, President Clinton and I proposed $47 million for watershed protection efforts, including nonpoint source pollution controls and wetlands restoration.

We are all keenly aware that our environmental efforts in the decade of the 90s must succeed. We must ensure that we leave to our children and grandchildren a healthy environment. Your attendance at this conference demonstrates that you are ready to take this challenge and make watershed protection work.

Sincerely,

Al Gore

Al Gore

Welcome

William H. Funk, President
Terrene Institute and Co-Chair of WATERSHED '93 Steering Committee
Washington, DC

Good morning and welcome to WATERSHED '93. The response to this conference has been overwhelming! There are about one thousand of us here today, and we're sorry to acknowledge that we had to turn away quite a few people.

What I think is most remarkable, though, is the broad array of disciplines and perspectives you all represent—citizen activists, technical experts, public program managers, farmers, industrialists, academics, and many more. About a third of us are from tribal, local, state, and interstate organizations—27 states and 19 tribes are represented. Another third of us are from the more than a dozen federal agencies that have sponsored the conference, including scores of regional and field office personnel. The balance of us represent business, agriculture, and the not-for-profit sector. In part this is due to the large variety of sponsors for the conference, but primarily I think it is in response to our very real concern that cooperative, comprehensive action must be taken to restore and protect our valuable water resources.

Over the next few days, you will hear directly from many of the sponsors, as they introduce speakers, participate on panels, or share information at their exhibits, or even during casual conversations in the hall or over meals. First, I have the honor to introduce to you my colleague and co-chair of the conference steering committee, Bob Wayland.

Remarks

Robert H. Wayland III, Director
Office of Wetlands, Oceans and Watersheds
U.S. Environmental Protection Agency and
Co-Chair of WATERSHED '93 Steering Committee
Washington, DC

It is especially fitting that we should be meeting at the onset of spring, the season of renewal, because this conference is not so much about the birth of ideas and institutions as it is their rebirth. In one of the most widely read texts about our global environment, we are reminded that

> Thanks in part to the scientific revolution, we organize our knowledge into smaller and smaller segments and assume that the connections between these separate compartments aren't really important. In our fascination with the parts of nature, we forget to see the whole. The ecological perspective begins with a view of the whole. But this perspective cannot treat the earth as something separate from civilization. We're part of the whole and looking at it inevitably means looking at ourselves.

I am sure few of us would disagree with these words from the author of *Earth in the Balance*, Al Gore. Our ancient forebears, in virtually all lands and cultures around the world, celebrated the connections in ritual, music, folklore, and literature. If they could see us, they would probably be amazed at our ability to produce food, transport goods and people, and fight disease and prolong life. But the condition of our natural world and modern society's attempts to heal it would surely disappoint them.

I hope that they might also understand, if they could see a videotape over time rather than a snapshot of 1993, that when the modern effort to control pervasive pollution began in the late '60s and early '70s we attempted to break the problem into solvable components. Much has been accomplished, looking at individual species, particular pollutant classes, or pollution source categories. But we have departed from what scientists would call the "first principles."

So WATERSHED '93 is about renewing our commitment to first principles. I hope we can strengthen and build upon a number of efforts to better integrate ecological protection and resource management. Specifically, we need to focus on efforts within particular geographical areas (such as Coquille Harbor estuary in Oregon, the Big Springs region of Iowa, and the Chesapeake Bay) and efforts to realign national and state programs to integrate approaches that have been separately directed to related problems (such as water pollution, agricultural production, fisheries management, wetlands protection).

Madison Avenue has trained us to think of one word when we're asked to spell "relief," but the vocabulary of holistic, integrated natural resource management contains many nouns and more than a few acronyms. Just think of a few—multi-objective river corridor management, TMDLs, habitat conservation plans, the National Estuary Program, Last Great Places. All of these are sound conceptual starting places for policies and actions that recognize *connectedness*. Many of us will learn a lot more about some of these nouns, perhaps we'll redefine them, and I hope that we'll add to the vocabulary of watershed management such terms as empowerment, expansion, and action.

Thank you very much.

A Historical Perspective on Watershed Management in the United States

Warren D. Fairchild
(Retired)
Consultant and Former Water Resources Planning Specialist, World Bank
Former Director, Water Resources Council, Alexandria, VA

I am honored to have been invited to participate in this very timely and significant conference on watershed management. I commend the sponsors of the conference for holding this workshop, which can be an important "springboard" for appropriate follow-up actions. It isn't as if the topic of watershed management has not been thoroughly discussed, studied, and analyzed before, but implementing desirable approaches has been "ad hoc" and marginally successful.

In my letter of invitation to speak today, it was encouraging to read the position taken by the prestigious Water Quality 2000 consortium on watershed management. Its stated position calling for taking a comprehensive, holistic approach to water management is a "breath of fresh air." It is a concept that I enthusiastically support and an endeavor to which I have devoted much of my professional life. Achievement of the Water Quality 2000 concept will prove to be difficult and illusive because no institutional arrangement exists to efficiently implement it and there are powerful forces that find such an approach conflicts with their self-interests. Many of you in attendance today may, wittingly or unwittingly, fall into this latter category.

The toughest part I had to fill in during preparation of this presentation was the third line of the title block. For the first time in my professional life, I have no official title. I am simply "Joe Smoe." This situation has its advantages. Unlike most of you, I represent no one but myself. I did not have to clear my remarks with anyone. Hence, the views expressed are mine alone, for which I am entirely responsible.

To many of you my name and background are most likely unknown because I have not been associated with domestic water resource programs for the last 16 years, during which time I was working on international water programs with World Bank. I am in a similar situation. As I look out over this conference, I recognize few participants—what a change for me from the early 1970s when I would have known most of the attendees on a first-name basis.

> "watersheds constitute the most sensible hydrologic unit within which actions should be taken to restore and protect water quality."
>
> —Water Quality 2000 Final Report, November 1992

Very briefly I would like to highlight some of my past 45 years of water resource experience as a basis for my message today to show that I have more knowledge on the subject than my title "retired" may suggest. I started my professional career in the late 1940s with the Soil Conservation Service in Nebraska doing soil surveys; preparing farm conservation plans; laying out terraces, grassed waterways, erosion control and irrigation structures; and designing grassland, forestry, and other conservation measures. In 1956, in the Gage County Soil and Water Conservation District, which I headed, there were six

watershed projects. These are excellent examples of micro-scale watershed management schemes requiring 75 percent land treatment prior to the installation of larger infrastructural measures.

While I was head of the Nebraska Soil and Water Conservation Commission, the first comprehensive State Water Plan was prepared. Two of the most memorable actions in my professional life ocurred during this tenure—enactment of the Natural Resource District (LB #1357) and Flood Plain Management (LB #893) legislation. The Natural Resource District legislation is "one of a kind" in the United States, and the Flood Plain Management program was a nonstructural approach to reducing flood damages. During this time, I also served on the Nebraska Water Pollution Control Board.

During the early 1970s, as Assistant Commisioner for the Bureau of Reclamation, among other things I was responsible for the comprehensive Westwide (water) Study for the 11 western states. It was during my tenure as Director of the U.S. Water Resources Council that the now well-known Principles, Standards and Planning Procedures were initially implemented by all federal water resource agencies. These procedures emphasized the two planning objectives of economic development and environmental enhancement. Also at this time the Second National Water Assessment was carried out.

> "Water by its nature is universal . . . . It is essential to programs in all sectors, whether the objective is economic development, social well-being, or environmental enhancement."

In 1976, I became associated with World Bank on water resource matters in South Asia and the Middle East. Even though I headed numerous appraisal missions involving investments in excess of a billion dollars, my most rewarding activities related to preparing water master plans for such countries as Pakistan, Bangladesh, and Yemen. These challenging planning efforts were heavily oriented toward policy and institutional reforms and adoption of natural resource management plans compatible with the physical environment, as well as the cultural background and technical capabilities of the people and their governments. My last significant World Bank activity was initiating a program leading to preparation of a strategy covering multisectoral water issues in the Middle East and North Africa (World Bank, 1992). This strategy is now being implemented.

As you can note from the above resume, much of my professional career has been devoted to comprehensive water resource planning. I wish I could assure you that all of these endeavors have been successful, but I can't. In many cases there have been strong individuals and powerful groups who saw such programs as threats to their vested positions. It is not unusual to find rational planning and wise management decisions falling victim to expedient political action where the "squeaky wheel gets the grease." Quite frankly, I wince at the extravagent and unfounded statements of vociferous individuals and groups, which many times are reported as fact by the news media eagerly awaiting the opportunity for sensational reporting. However, there have been a sufficient number of successful comprehensive watershed management programs carried out to be encouraging. With the clout of groups like Water Quality 2000 and the stated interest of the new administration in this field, the time may now be ripe for a breakthrough. Hopefully, this interest by the Clinton administration will not be misguided.

Water by its nature is universal and fortunately it is a renewable resource. It is essential to programs in all sectors, whether the objective is economic development, social well-being, or environmental enhancement. Unfortunately, there is no overall entity responsible for the total management of water and other natural resources. In most countries, as in the United States, the administrative organization of government is not conducive to sound and holistic watershed planning and management. For the most part, governments are organized along functional lines, (e.g., agriculture, transportation, health and human services, environment, energy). Water management is further fragmented by layers of government at the federal, state or provincial, and local levels. Thus, a major obstacle to achieving comprehensive and holistic management of natural resources is the lack of institutional arranagements that can efficiently facilitate such an approach.

Water became a national concern long before many of the current priority governmental programs were instituted. Federal

involvement in most programs was delayed because of the constitutional issues concerning the federal role, vis-a-vis the role of the states, local jurisdictions, and the private sector. For example, the states retain a very significant water role because of their regulatory authority over water use and rights. This is particularily evident in the arid western states.

The first federal water programs began in 1824 with congressional enactment of the General Survey Act, which authorized the Corps of Engineers (COE) to make surveys and estimates on schemes deemed to be of national importance (USDA, 1972). Planning authority was not included in this act, but was authorized in 1826 in the first omnibus Rivers and Harbors Act. These early acts were limited to navigation. A major objective of these and other early federal mandates was to facilitate westward migration of settlers.

It was not until the mid 1800s that the Corps became involved in flood control. In 1879, the U.S. Geological Survey published a survey on the sparsely settled dry lands of the West. This report sparked government action to reserve right-of-way for irrigation canals on public lands west of the 100th meridan and paved the way for the 1902 Reclamation Act. In 1891 Congress enacted national forest legislation with flood control as a major consideration.

As the values and priorities of the country shifted, additional natural resource assignments were made and new agencies were established. For example, the Forest Service was established in USDA in 1905. Beginning in 1912, the Public Health Service was authorized to study and disseminate information on the public health aspects of water pollution. However, it was not until 1948 that it became actively involved in water pollution abatement. The Federal Power Commision began functioning in the 1920s, and the Tennessee Valley Authority was created in 1933 (USDA, 1972). Following the disastrous "dust bowl era," the Soil Conservation Service (SCS) was established in 1935; however, it was not until 1956 with enactment of Public Law 83-566 that SCS had a significant watershed operational program. Environmental programs were strengthened considerably in the 1970s with enactment of the National Environmental Policy Act (NEPA), establishment of the Environmental Protection Agency, and passage of the Endangered Species Act.

The above list of water assignments is not exhaustive, and quite frankly there is a void in my knowledge of such programs during the last 16 years because of my international service. Even so, the above recounting indicates the evolution of federal water agencies, as well as the specificity of their assignments as the Congress and executive branch strove to be responsive to evolving values relating to natural resource issues. Similar institutional arrangements were developed in the states—partially reflecting need but also to take advantage of any federal largess that could be forthcoming. Simultaneously, or even preceeding the establishment of these executive agencies, was the formation of vested interest groups and congressional oversight committees—hence, the development of a strong triad (i.e., congressional committees, federal agencies, and related user or lobbying groups) to protect and enhance specific activity with inadequate consideration as to how such activities affect water programs in other sectors or what is most important in the national scheme. This arrangement worked well in earlier times when water was in surplus and new land remained to be settled. Many outstanding works completed under such arrangements have had significant and overall positive impact on our nation's development. However, this approach is entirely outmoded in today's environment of conflicting uses for scarce and dwindling resources.

> "Unfortunately, the United States does not have a well-articulated and comprehensive natural resource policy."

Unfortunately, the United States does not have a well-articulated and comprehensive natural resource policy. The policy that it does have is scattered in a myriad of legislative acts, administrative orders, and regulations that have evolved over time. Not too surprisingly, there are gaps and conflicts in these documents. Benefit-cost analysis for federally assisted water projects began in the 1930s. Also in the 1930s some effort was directed at cost-sharing arrangements. However, for the most part these and other policy-related issues were secondary and largely ignored by the agencies. They had little congressional support and were actively opposed by most user groups.

Probably the first effort to coordinate water resource activities was the appoint-

ment of an Inland Waterways Commission by President Teddy Roosevelt in 1908. However, little came out of this and subsequent activities until 1993 when President Franklin Roosevelt created a National Planning Board as part of the "New Deal." Its charge was to prepare a program of public works including water works. Many of these schemes were implemented under the Public Works Administration (PWA). Also included in the Board's reports was a program calling for multiple-purpose reservoirs for 10 river basins based largely on COE river planning documents known as 308 reports. This resulted in construction of such dams as Grand Coulee, Parker, Bonneville, Shasta, Fort Peck, and Wheeler. Thus the era of multipurpose reservoirs came into being—a first step toward holistic watershed management. However, multipurpose development should not be confused with the all-encompassing holistic watershed management approach as envisaged today.

The National Planning Board and its successors never had much support in Congress, and in 1943 Congress abolished it as part of its continuing battle with the executive branch over control of water programs. At about this time the responsibility for coordinating water planning was assigned to the Bureau of the Budget (BOB), which in my estimation was and continues to be a mistake. BOB's position, and that of its successor the Office of Management and Budget (OMB), is based on biases reflecting perceived impacts on the federal budget and little else. This "short changes" natural resource programs and the totality of their impact on society.

Following World War II a series of actions and institutional arragements were instigated to facilitate sound planning and coordination of water resource agencies. In 1952, BOB issued the A-47 directive to water agencies precribing planning standards they were to follow. With the dissolution of the Natural Resources Planning Board, Agriculture, Interior, War, and FPC entered an agreement to coordinate their separate responsibilities in preparation of basin surveys. This agreement established the Federal Interagency River Basin Committee—better known as "firebrick—which, in turn, set up interagency committees on specific river basins. Provision was made for state participation. Some River Basin Interagency Committees carried out very extensive programs, as exemplified by the "Pick-Sloan Plan" on the Missouri River. "Firebrick" issued the "Green Book" covering economic analysis of river basin projects, but the Bureau of Reclamation and COE did not fully accept it for their projects.

Under the Eisenhower administration "firebrick" was reorganized with members at the subcabinet level to include the Department of Health, Education and Welfare with the Departments of Commerce and Labor to serve as associates. This interagency committee for water resources can best be remembered by the moniker "ice water." "Ice water" did not make any policy recommendations; however, a Presidential Advisory Committee on Water Resources Policy did make policy recommendations to Congress on planning, which were cooly received.

There were a myriad of executive and congressional water study commissions and committees established in the 1950s; however, for the most part the reports and recommendations of these bodies were ignored as the struggle continued between the executive and legislative branches over control of the water programs. An exception was recommendations of a "Select Committee on National Water Resources," chaired by Senator Kerr, which resulted in enactment of the Water Resources Planning Act (P.L. 89-80) in 1965.

Primarily, the Water Resources Planning Act provided for (1) establishment of the Water Resources Council (WRC); (2) organization of Federal/State River Basin Commissions; and (3) financial assistance to states for water planning. Having served as a Director of WRC, it is my opinion that this act and initiatives coming from it were significant, and given the political environment at that time, it was about as comprehensive a piece of legislation as could have been enacted. WRC was only as strong as its members desired or permitted. At times this was a distinct weakness when proposed actions came into conflict with the programs of a member agency. WRC was successful in promulgating the "Principles, Standards and Procedures" for water resource planning, completing two important National Water Assessments, and organizing six River Basin Commissions. These Federal/State River Basin Commissions completed some very sound interagency plans, which have come as close to the concept of holistic basin (watershed)

management as we have achieved in our nation. Financial assistance to the states led to the preparation of many fine State Water Plans, which for the most part were consistent with the holistic concept.

WRC and the River Basin Commissions were inherently weak because they had few stalwart clients. They had no hardware to sell. As WRC tackled hard policy issues on cost sharing and planning procedures envisaging tougher economic analysis or environmental enhancement, it found itself in conflict with OMB and Congress. In many ways OMB saw WRC as usurping its water policy and coordination roles. At that time, Congress wanted little executive branch action in these areas because it could interfere with congressional flexibility in providing projects and programs to constituents. I still remember some of the testy "Hill" hearings on these subjects.

Another WRC weakness was requiring its eight members to be at the Cabinet level. Cabinet members are busy people, and it is difficult to get them together for meetings. This was rectified during my tenure by designating subcabinet members (generally Assistant Secretaries) as Associate Members authorized to take action in name of their respective members. The Associate Members met quite regularly. A high point during my WRC career was when OMB officials walked out of a meeting of WRC members during discussions on cost sharing associated with a congressionally directed section 80 study. WRC members wanted to increase cost sharing over time, while OMB wanted high levels immediately.

Five years after I left the Council, it met an inglorious death at the hands of Secretary of the Interior James Watt, who was of the mistaken opinion that all water resources programs could be coordinated out of the Department of the Interior. Agencies will not tolerate coordination of their assigned functions by another agency.

In conclusion, it is my opinion that the two keys to achieving a satisfactory level of holistic watershed management are (1) rational comprehensive planning and (2) compatible institutional arrangement to facilitate implementation. This will require some reorganization within both the executive and legislative branches. I do not have much hope for success for such an initiative unless there is a committee in Congress that has overall responsibility for actions related to comprehensive watershed management.

Within the executive branch it would be folly to expect reorganization of all water agencies into one federal department. Politically, I doubt if such a reorganization could be accomplished, and there remains merit to governmental alignment along functional lines. However, there is good reason to believe that an umbrella organization could be established with comprehensive natural resource policy and planning responsibilities. Among other things, it could be charged to prepare an appropriate policy framework for watershed management. This arragement should afford opportunity for input from the various federal agencies and provide for state participation plus input from various interest groups. Comprehensive and holistic watershed management plans could then be developed for each major basin and/or region by an interagency federal/state commission. Once an agreed-upon watershed management plan has been produced, individual agencies, organizations, and the private sector could be called on to implement portions related to their appropriate roles.

"two keys to achieving a satisfactory level of holistic watershed management are (1) rational comprehensive planning and (2) compatible institutional arrangement . . ."

In essence, I am suggesting that you take another look at the Water Resource Planning Act (P.L. 89-80). Most likely you will find something of value in it. With a little revision, it may serve as a vehicle or guide for meeting your lofty and desirable goals of sound watershed management.

As for planning, it is a continuing process. Sound planning procedures must be articulated and followed. Macro planning should be heavily policy-oriented and provide for sustainable benefits. The totality of the natural resource base must be fully considered. Alternative plans must be displayed so that decision makers can understand the options available and the trade-offs involved in their decisions. Plans must be designed to be compatible with the physical environment and reflect social values. All plans should be subject to stringent economic analysis while providing appropriate environmental safeguards. It is

my view all regulatory measures should be similarily tested. If found uneconomical or environmentally unsound, a strong justification on other grounds should be presented if a proposal is to go forward to higher-level decision makers.

Again, thank you for inviting me to appear on your program. The issues to be discussed by you during this conference are extremely important and the manner in which they are addressed will have a profound effect on our nation's future. I welcome the opportunity to visit again with professional colleagues on significant significant watershed management issues. It is good to become so involved once more. I wish you well in your deliberations.

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The Current State of Watersheds in the United States: Ecological and Institutional Concerns

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The significant problems we face cannot be solved at the same level of thinking we were at when we created them.
—Albert Einstein

Reason and free inquiry are the only effectual agents against error.
—Thomas Jefferson

The National Research Council (1992) book *Restoration of Aquatic Ecosystems: Science, Technology, and Public Policy* recommends restoration of entire systems. This volume espouses restoration at the landscape level, which means restoring aquatic ecosystems per se and also the drainage basin that so strongly influences the character of any ecosystem. The book is divided into the traditional freshwater aquatic ecosystem compartments of rivers, wetlands, and lakes because the academic profession commonly compartmentalizes aquatic ecosystems in this manner, and, consequently, knowledge is organized in these compartments despite the fact that all are merely components of a hydrologic cycle that includes clouds, ground water, and water in vegetation. All this compartmentalizing illustrates that adopting a systems- or landscape-level perspective has consequences that have not received the attention they deserve. Some illustrative examples follow.

At best, only a primitive understanding exists of whole-ecosystem or landscape-level management, but we do know how to do restoration and can continue to learn!

Most articles in prestigious ecological journals focus on populations (or other specific aspects) rather than on systems. Harte et al. (1993) provide a fascinating analysis relevant to this situation:

> If we turn to the current journal literature in ecology and conservation biology, we will not get as much help as we would like. Figure 7 [adapted as Figure 1 in this discussion], based on our survey of all the articles appearing in some recent volumes of leading journals, illustrates the 'Pluto Syndrome' that afflicts ecology today. It shows that most research in ecology might just as well have been carried out on the planet Pluto—climate and the chemical and physical properties of the soil, the water, and atmosphere of Earth were irrelevant to the research. Even in the 22% of the articles that mentioned at least one of these factors, the reference was generally made as part of a site description and played no role in the interpretation of results. In none of the papers surveyed were the interactions among these factors even mentioned.

At present, robust examples of effective integrated, landscape-level management are rare.

In short, the institutional focus is on components of whole ecosystems, such as wetlands, lakes, rivers, etc., and not the entire system, although sometimes lip service is

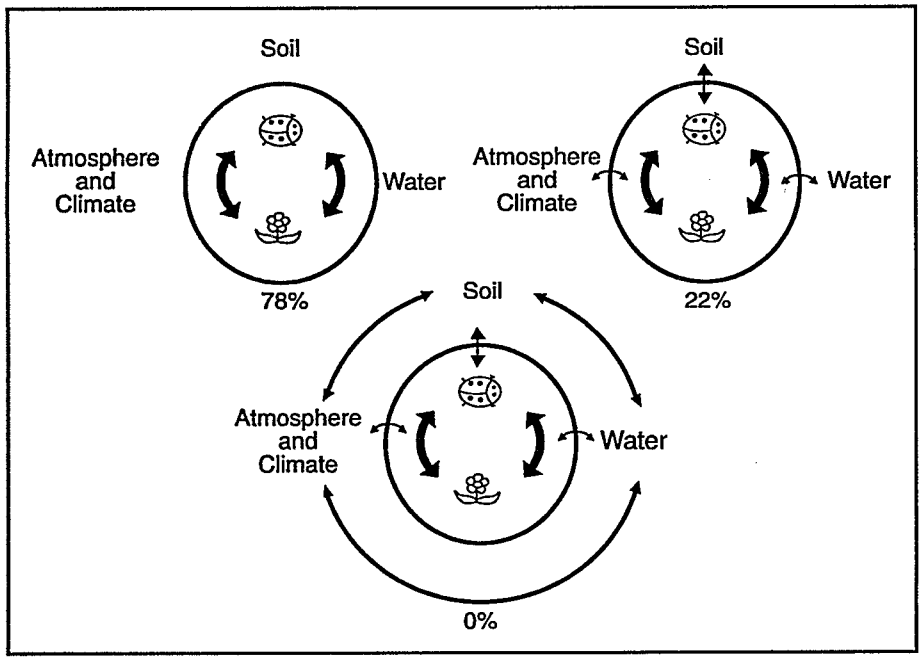

Figure 1. Results of a survey of the recent journal literature in ecology, indicating the dominance in ecology of research that ignores the influence of climate, soil, water, and air on species interactions. All 285 articles in four consecutive issues during 1987-1988 of the journals *Ecology, American Naturalist, Oecologia,* and *Conservation Biology* were surveyed.

given to this. Many cases are concerned with a primary purpose (e.g., flood control) or a primary species (e.g., cattle or deer). Current efforts to stress watershed management are still focused on components (such as water quality).

Present regulatory measures and agency policies, which focus predominately on components of whole systems (bottom-up approach), most likely cannot be modified to produce a scientifically justifiable whole-ecosystem management plan.

A new policy then must be articulated. Two general approaches have been used to evaluate the ecological risk associated with various human activities (Norton et al., 1988). A bottom-up strategy emphasizes laboratory experimentation and modeling to provide information with which to predict the fate and effects of different anthropogenic stressors that may be introduced into the environment. Ideally, such protocols are arranged in a tiered fashion (e.g., Kimerle et al., 1978), proceeding from relatively simple and inexpensive laboratory screening or rangefinding tests to predictive and confirmative tests (carried out in both controlled laboratory and field test systems) and, finally, the surveillance of natural receiving systems to validate the degree of risk estimated in the experimental tiers of testing. Each tier culminates in a decision-making process, which is used to determine the amount and nature of testing required at successively higher, and inevitably more costly, tiers.

It is virtually certain that a top-down management approach (starting with the entire system and sometimes working down to components) will be a necessary replacement of the bottom-up approach (starting component by component and sometimes intending, but usually failing, to work up to the entire system).

Agencies and programs are also organized in bottom-up sequence; in addition, many agencies have narrowly trained people because their agencies are so narrow. Most professionals are specialists trained to work with a component of a system, even though the profession may suggest that they are accustomed to systems-level activities. For example, most ecologists are actually population biologists and not systems-level ecologists, although they may purport to be systems scientists in theory.

The bottom-up approach works well only when a low-density, low-energy society "lies lightly" on the ecosystem it inhabits.

The component-by-component approach is not as effective when a dense population with high per capita energy consumption is competing for an ever-diminishing natural resource base.

When the United States was first settled and the population density was trivial compared to today, cities were small and widely dispersed so that substantial amounts of relatively undisturbed ecosystems separated them. Even on rivers after the Industrial Revolution began, the discharges were usually small in volume, relatively rapidly degradable, and relatively nontoxic compared to those of today. Therefore, dilution frequently solved the problem, and, even when it did not, the river had an opportunity to recover because of the spacing and relatively low impact of the discharges. In one industrialized area, I

recently counted 28 discharge pipes on both sides of the river and even from an island that contained industrial buildings in a distance of less than a half mile. It was impossible to separate the effects of each of the discharges in the river itself because of their proximity, toxicity, and volume. If they had all come from a single industry or municipality, the problem could have been resolved by a single collection and treatment system for the wastes, but they were from multiple industries and one municipality. Had the waste discharges been widely separated, it would have been possible to determine the ecological effects in the receiving system (in this case a river), and it would have been possible to determine a no-observable-effects level by toxicity tests, followed by validation of the predictions in the receiving system itself. When aggregate effects occur in a relatively restricted area, a component-by-component approach simply will not work. A top-down management system to determine the acceptable aggregate effect of all of the discharges on the receiving system must be designed, and a strategy must be developed for allocating beneficial nondegrading use of the river so that all dischargers get some benefit but none can continue present practices if they lead to biological impoverishment.

A protocol for selecting the best possible waste disposal option (air, land, or water disposal) must involve comparisons of waste impact in ecologically dissimilar ecosystem compartments.

The information base must include the effect not only on the compartment into which the waste is initially placed, but also the impact on the entire system into which it is placed. Toxicity tests at single-species levels will not be particularly useful in making decisions at the landscape level because they represent totally different levels of ecological organization—extrapolation from lower to higher levels cannot be done with sufficient precision. Determining the best possible waste disposal option or considering multiple use of a limited natural resource will both involve trade-offs. Obviously, trade-offs require more skillful negotiations and almost certainly more robust information than the simple "go" or "no go" decisions characteristic of the past. There is always uncertainty about environmental outcome. The industrial group could, and probably should, gather more evidence, but there will never be enough to predict an outcome with absolute certainty. Therefore, when the evidence of no effect seems scientifically justifiable (and 100 percent certainty is never scientifically achievable), financial bonding to repair ecological damage may satisfy both the environmental organization and the regulatory authorities. If, in fact, some damage not predicted by present evidence occurs, ecological repair will be carried out. Despite the enormous reluctance of the general public and their legislative representatives to admit this, there is no zero risk action for any developmental activity. Neither is zero environmental impact possible even if zero discharge is achieved because recycling requires energy and generally generates some waste products, both of which will have an environmental impact somewhere. It is possible, of course, that the environmental impact may not be where the products are generated, but rather elsewhere where fossil fuels are obtained, nuclear power materials are stored, or electricity is generated.

Opportunity-cost analysis should replace the traditional cost/benefit analysis used in most environmental decisions because the question should become: How can limited economic resources be used most effectively in landscape-level management?

Management at the systems level requires a "common currency" that allows comparison of the societal benefits of a proposed alteration or use of one part of the system with overall system benefits and costs. Such a strategy would provide both (1) a basis for policy decisions and regulatory measures at the systems level and (2) a means for arbitrating disputes in multiple use of a single resource or the use of one resource that damages another resource. Shabman (in press) provides more information on the rationale for opportunity-cost analysis. An early paper on the theory of developing value measurement tools was written by Batie and Shabman (1982). A concomitant component of opportunity-cost analysis is adaptive management (e.g., Lee and Paulsen, 1990).

A "common currency" must be developed for optimizing trade-offs and comparing long-term sustainable use benefits to short-term benefits.

As already mentioned, in the optimal disposal option selection or any other

multimedia decision, comparisons between ecosystems with quite different attributes will become inevitable. Although ecologists are understandably reluctant to make such comparisons, particularly when practically all their experience has been in a limited array of ecosystems, such decisions must inevitably be made. In addition, it is essential to provide a means for comparing long-term (or sustainable use) benefits to short-term benefits, which might either impair long-range benefits or require costly corrective management when the alteration no longer serves its original purpose. An example of this situation would be a dam behind which silt has accumulated (especially sediments with a heavy burden of persistent toxic materials). The dam may no longer hold the pool of water that matches the original storage capabilities, and the water may contain fish and other wildlife with dangerous body burdens of hazardous materials that pose a threat to both the biota and human health. The common currency most suitable for such comparisons is ecosystem services, which are defined herein as those functional attributes of natural systems perceived as valuable to human society. Illustrative ecosystem services include maintenance of the atmospheric gas balance, maintenance of water quality, maintenance of an array of species (some of which may provide chemical models for human drugs), or maintenance of a species suitable for aquaculture. Mitigation for impaired or lost ecosystem services would require restoration of some part of the larger system in compensation for these services lost to society or, alternatively, when possible, substituting continually operating technological systems to provide comparable services. In this way, sustainable use of natural systems is ensured because there would be no net loss of ecosystem services.

This approach would require a major readjustment of the federal structure, but this is already underway as part of the deficit reduction and other initiatives of the new administration. However, management of systems, if skillfully carried out, is always more efficient than management of components of the system, particularly when intense (and not always compatible) use results in continual conflicts that are difficult or impossible to resolve at the component level.

Ecosystem Services and Human Population Size

If ecological destruction continues at its present rate, it is virtually certain that no sizable, relatively undisturbed ecosystem will remain, even if the world's oceans are included. In addition, abundant evidence indicates that fragments of ecosystems cannot maintain viable populations of many species, and, with a few notable exceptions, these populations cannot be maintained in zoos at a cost acceptable to human society. Similarly, if the human population continues to grow at its present rate, the quality of life will almost certainly deteriorate below present levels, which even now are not satisfactory to much of the world's existing population. Even in an affluent society such as the United States, many parents realize that their children will be unable to live at a level of affluence comparable to theirs. Human society has been able to reach its present level of affluence and population density by exploiting a one-time bonanza of ecological capital, including old-growth forests, fossil fuels, metals and minerals, biomass of harvestable species, and fossil water, to mention a few examples. However, sustainable use of our ecological life support system requires that we focus on the services of ecosystems that can be utilized without destroying ecological capital. Developing policy at the landscape level will depend on integrating water and land management, and most of the assumptions and recommendations apply equally to both. The policy recommendations that follow are based on these four assumptions:

1. Ecosystem services are important to the survival of human society in its present form.
2. The continued destruction of ecosystems and the concurrent rapid increase in human population size are serious threats to the delivery of ecosystem services.
3. The rapid global loss of species intimately connected with the loss of habitat will also impair the delivery of ecosystem services.
4. Healing damaged ecosystems will enhance both the quality and quantity of ecosystem services.

There are five basic policy options regarding the relationship of ecosystem services and human population size and affluence:

1. Continue ecosystem destruction and population growth at their present rates and see what happens before any action is taken. This would mean dramatic erosion of ecosystem services per capita in the near future.
2. Adopt a policy of no net loss of ecosystem services—a balance between destruction and repair must be achieved at all times. This would still mean a decline of ecosystem services per capita but less rapidly than option 1.
3. Exceed a no net loss of ecosystem services—develop a policy of healing or restoring ecosystems at a more rapid rate than their destruction. This would still mean a loss of ecosystem services per capita at the present rate of population increase.
4. Stabilize human population growth and exercise option 2. This would maintain the status quo on ecosystem services per capita.
5. Stabilize human population growth and restore ecosystems at a greater rate than damage. This would improve ecosystem services per capita.

If we decide to restore ecosystems at a rate equal to or greater than their rate of destruction, these basic elements should be part of a national and global restoration strategy: restoration goals and assessment strategies should be set for each ecoregion; principles should be established for priority setting and decision making; and policy and programs for federal and state agencies (or the United Nations) should be redesigned to emphasize ecological restoration.

The National Research Council (1992) had the following illustrative goals for the United States for restoring aquatic ecosystems between now and the year 2010: (1) wetlands—restore 10 million acres (out of 117 million impaired or destroyed since the year 1800); (2) rivers and streams—restore 400,000 miles (12 percent of the 3.2 million miles presently considered impaired or damaged); and (3) lakes—restore 2 million acres (out of 4.3 million acres presently degraded). Although precise replication of predisturbance condition will rarely be possible, achieving a naturalistic assemblage of plants and animals of similar structure and function to the predisturbance ecosystem should be possible in most cases. However, if one adds the attributes of self-maintenance and integration into the larger ecological landscape in which the damaged patch occurs, both the temporal and geographic dimensions of the study area increase substantively. If exploratory restoration projects are added in each ecoregion, then the number of acres and the percent or actual size of the restored aquatic ecosystems just given do not appear excessive. The recent *World Scientists' Warning to Humanity* (Union of Concerned Scientists, 1992) states "Human beings and the natural world are on a collision course." Ecological restoration is a means of buying more time for human society to develop lifestyles less threatening to natural systems and for ecologists to develop more robust methods for restoring the earth's damaged systems.

Societal Integrity vs. Ecological Integrity

Ecological integrity can be defined as the maintenance of the structural and functional attributes of a particular ecosystem, including natural variability and such temporal processes as succession. The events in Somalia and Yugoslavia, as well as the equally dramatic (but, thus far, more peaceful) events in eastern Europe and what was once the USSR, have focused world attention on societal integrity. Our present human society globally has reached its level of affluence and density because of two life support systems—one technological and the other ecological. However, the events since the beginning of the Industrial Revolution clearly indicate that most human societies place far more value on the technological life support system than on the ecological one. In the last few decades, the shift has been toward a recognition of the duality of the life support system and an attempt to give more value (frequently in religious or mystical terms) to the ecological life support system. In the United States, the lumbering of the old-growth forests in the Pacific Northwest, of which only 10 percent remain, has dramatically focused attention on this issue. Arguably, the Clinton administration has given more attention to this particular ecological problem by a high-visibility visit to the area. Some groups still advocate continued lumbering of the remaining 10 percent of the old-growth forests in order to maintain the social integrity of the towns and industries that are benefiting financially from timber harvesting and sales. In some cases, even the realization that harvesting all

remaining old-growth forests would maintain the societal integrity for only a few more years does not deter some people from the position that the societal integrity is worth the loss of the old-growth forests. Although emotions are strong in the small towns in the region dependent upon the logging of old-growth forests, a substantial number of citizens in the country as a whole, perhaps even a majority, want the ecological integrity maintained close to its present level, even if this means retraining loggers and the logging industry for some other economic activity. The government might subsidize this retraining to some extent, as is likely for military bases where an old technology is being replaced by a newer one.

Although the economic advantages of societal integrity of the technological life support systems have been appreciated by human society for generations, the benefits of ecological integrity as part of the societal life support system have not. Perhaps ecosystem services will enhance our understanding of the crucial and necessary balance between technological and ecological life support systems. Even if this balance is achieved by global society, it will almost certainly not be enough to heal the damaged ecological life support systems and to maintain them in a robust condition.

Going Beyond Ecosystem Services

I regard the relationship between human population size and the maintenance of ecosystem services as extremely important. However, the quantity of ecosystem services, and possibly even the quality, might not be diminished even if many species now inhabiting the earth were lost. If the concept of ecosystem services is interpreted narrowly (i.e., excluding attributes other than those necessary for human survival), then human society might forego preserving as many as possible of the species with which we share the planet. If broadly interpreted, ecosystem services might well include the honking of geese flying overhead, the mating dance of the whooping cranes, or just knowing that the snow leopard still exists even though most of us will never see one in its native habitat.

I have espoused the idea of preserving ecosystem services in the hope that enlightened self-interest of human society will arrest or, better yet, reverse the environmental destruction that marks the end of this century. However, human society has an ethical responsibility that should go well beyond self-interest to assumptions of fairness, equity, and the common good of all the species on our planet. It is, of course, impossible for all of us to develop a feeling of kinship with each of the more than 50 million species estimated to inhabit the planet at present. It is not beyond our grasp, however, to feel a kinship with the habitats and natural systems upon which the survival of our fellow species depends. To do this, we must develop an ethos, or guiding belief, in both the government and its citizens. The respected Athenian leader and general Pericles noted that the chief safeguard of his society in 431 B.C. was that citizens obeyed the customs and the laws "whether they are actually on the statute book, or belong to that code which, though unwritten, yet can not be broken without acknowledged disgrace" (Thucydides, book 2, Chapter 6, 37). The development of an ethos and fairness toward our fellow species will not by itself be enough unless accompanied by a widespread improvement in environmental literacy.

Acknowledgments

I am indebted to Luna B. Leopold, who started his magnificent Abel Wolman Distinguished Lecture, given in February 1990 at the National Academy of Sciences, with a reminder to us of Pericles' address to the citizens of Athens following the end of the first year of the Peloponnesian War. It was refreshing, in this litigatious era in the most litigatious society on earth, for a respected scientist to begin a discussion of water resources utilization by discussing equity and fairness. I am also indebted to my colleague B.R. Niederlehner for comments on an early draft; to Teresa Moody for transcribing a number of drafts of this manuscript, as well as entering alterations on the word processor; and to Darla Donald for final editing of the manuscript. I appreciate the assistance of Dianna Freeman in the editorial office of the Society of Environmental Toxicology and Chemistry for locating the source of the Thomas Jefferson quote.

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A Charge to Conferees

John B. Waters, Chairman
Tennessee Valley Authority, Knoxville, TN

When I was asked to speak at this opening session, I was told, "You won't have to say much . . . just inspire the audience to greatness during the course of the conference." Of course they did not tell me about the "inspiration" and "greatness" parts until after I had agreed to speak.

Frankly, I do not feel all that comfortable about trying to inspire such a distinguished group. But I do feel comfortable about discussing greatness because I think we can get a head start on achieving it before this week is out.

This is the first national conference devoted to a total watershed approach, to pollution prevention, and natural resource management. History may well look back on this conference as a watershed itself—a watershed event in our nation's struggle to deal with sustainable resource development.

Some of our nation's first attempts at watershed management amounted to exploiting the land and water and then working to reclaim them. Later, the Tennessee Valley Authority (TVA) and other organizations used another approach—large-scale projects to tame the rivers. Today, like many of your organizations, TVA is facing new and different challenges in watershed management, and we are working to find the best way to meet those new challenges. Let's take a closer look at each of these approaches to watershed management.

I come from east Tennessee. Like folks in some other parts of the country, Tennesseans have seen watershed development in its earliest and worst forms. In the southeastern corner of Tennessee, there is a large bowl-shaped valley surrounded by mountains. I suspect many of you are familiar with it. It is called the Copper Basin. Gold seekers began exploring the Copper Basin in the 1800s. They did not find much gold, but they found something almost as valuable—copper.

The first copper smelter was built in 1854 when miners heated the ore over open fires fueled by timber from the surrounding forests. By the turn of the century, virtually all the forests within hauling distance had been cut, and sulfur dioxide fumes from these early smelters had destroyed the area's remaining vegetation. The land was bare. Erosion was hauling off soil at a rate of 2 to 3 inches a year. Streams filled with silt, and the acids and heavy metals killed the fish and other aquatic life.

Then came the blast furnaces with tall stacks to send sulfur dioxide fumes across the state line into north Georgia. Naturally, the people in Georgia were pretty upset about this devastation spreading into their land. Georgia filed a lawsuit against the Tennessee Copper Company, which controlled all the copper smelters. They were suing to stop the acid rain, although nobody called it "acid rain" back then.

Georgia took the case to the United States Supreme Court in 1907 in one of the first major environmental lawsuits in this country, and Georgia won. The Tennessee Copper Company was forced to recover the sulfur dioxide fumes; and when they did, they discovered an amazing thing. The sulfur dioxide they had been spewing into the air was valuable. They could turn it into sulfuric acid, which was badly needed to make fertilizers. In fact, once the company started producing sulfuric acid, it became their leading product and copper was a secondary item. That stopped the exploitation of the Copper Basin, but that was not the end of the Copper Basin story.

When TVA came along in the early 1930s, the land was worse than useless.

Gullies were so deep you could hide a bulldozer in them. Fifty square miles of countryside had become a moonscape. The Ocoee river, which runs through the Copper Basin, was a river of silt. TVA, the Soil Conservation Service, the Tennessee Copper Company and its successors, and others went to work on the problem. They plowed, they planted, and they fertilized for generations. And finally, all the hard work began to pay off.

In recent years, thanks to a combination of hand planting and aerial seeding and fertilizing with helicopters, the land is coming back to life. Three-quarters of the original 50 square miles have been restored. The barren land of the Copper Basin used to be a familiar landmark to astronauts orbiting the earth. Today it supports a broad variety of hardwoods, shrubs, and grasses and provides a habitat for wildlife. The scars of the Copper Basin are healing. They are becoming invisible not only to the astronaut but also to the motorist on Highway 68 driving through the heart of the basin from Copperhill to Ducktown. I am telling you this story about the Copper Basin because it may well be America's foremost case of watershed destruction. The Copper Basin shows us that our old model of exploitation and reclamation just doesn't work.

> "our old model of exploitation and reclamation just doesn't work."

A more recent model for watershed development is found in the roots of the organization I represent—the Tennessee Valley Authority. Sixty years ago this nation began a great experiment when President Roosevelt proposed this new approach to watershed management. He asked Congress to charge TVA with "the broadest duty of planning for the proper use, conservation, and development of the natural resources of the Tennessee River drainage basin for the general social and economic welfare of the nation."

It was a marvelous challenge, and TVA set about meeting it by building dams and developing the river. The dams controlled the floods that ravaged the bottomlands and towns every spring. The new lakes created a navigation channel that opened up the region to trade with the rest of the Nation. The dams also provided electric power that attracted industry into the valley, creating jobs and bringing light and comfort into people's lives. It was a great vision and it worked magnificently; but the era of large-scale water-development projects, for the most part, is over.

The emphasis of national water management policy has shifted. Today we are focusing on water quality, water conservation, and managing resources to meet a wide range of demands. Developing water resources was the easy part. Today's challenge is learning how to manage those resources after they have been developed. To succeed, we must have a new framework, a new way of managing resources, a new model or paradigm that meets today's needs. What we need today is a paradigm shift in the way we view watersheds.

Paradigm shifts occur when we discover a revolutionary way of looking at the world, a vision that changes our old way of seeing, that opens up new horizons. A classic example is the change in the way we view the solar system. The ancient Greeks saw the solar system as revolving around the earth, but the 16th century Polish astronomer Copernicus realized that the solar system revolves around the sun. This change in perception was a paradigm shift, and its impact was felt far beyond the field of astronomy.

At TVA we are taking the first steps toward a new model of watershed management. We have moved beyond the old engineering model of large-scale development, and in its place we are substituting environmental principles, integrated resources planning, partnerships with other agencies and organizations, and public participation.

Recently, TVA completed the first major assessment in 50 years of the way we operate the Tennessee River system. As a result of this reassessment of the river system, water quality and recreation now stand alongside navigation, flood control, and power production as the major factors determining how we operate our dams and lakes. We are also setting up river-action teams that work with individuals, communities, and corporations in each of the 12 major watersheds that drain into the Tennessee River. The river-action teams, made up of scientists and engineers, help solve water quality problems in each watershed.

TVA also has helped set up lake-user groups made up of interested citizens around

several of our lakes. The various lake-user groups get involved in local issues, such as pollution control and land use, that affect the lakes. TVA also publishes an annual state-of-the-river report called *RiverPulse*, which describes with colorful graphics the water-quality conditions of each of the lakes in the TVA system.

Three years ago I made a 10-day inspection tour of the Tennessee River. About 1,000 state and local leaders and other interested citizens rode with me on portions of our journey down the river. We talked about such issues as developing urban waterfronts, protecting scenic natural areas, managing wastes, and controlling nonpoint source pollution. It was an opportunity for all of us to learn more about the river and to see it from different perspectives, and it was in keeping with TVA's efforts to increase public awareness and involvement.

Now I do not mean to stand up here and tell you that TVA has come up with the all-purpose answer to watershed management. We have not, but we do have a piece of the answer, and we are building on it every day. And TVA is certainly not the only one here that is working on a new model for watershed management. Many other organizations have great ideas to share, and many of you are bringing those ideas to this conference.

I want us to share those ideas and to combine the best of them into a new model, a new paradigm, of watershed management. This is my challenge to you during the next 4 days. I am convinced that the information needed for a new model of watershed management is here in this very room. We have a remarkable opportunity with all this knowledge, all this expertise, and the willingness to share ideas and experiences. We have the critical mass. All we need to do is put our ideas and energies to work. Answering the challenge is up to us.

> "We have moved beyond the old engineering model and we are substituting environmental principles, integrated resources planning, partnerships, and public participation."

Remarks

Addressing Multiple Interests

G. Edward Dickey, Ph.D.
Acting Assistant Secretary of the Army for Civil Works
Washington, DC

Before I introduce our notable panel this morning, I want to share with you a few of my own perspectives on watershed management.

I've had the pleasure of being associated with the Army Corps of Engineers (COE) Civil Works program since 1973, so I've witnessed an enormous evolution in the program and, indeed, in federal programs generally. Certainly, as we look at the COE Civil Works program today, we realize that it is the manager of an enormous inventory of completed waterway projects and multipurpose reservoir systems—projects that have a replacement value of $125 billion.

Now these typically very large projects, especially the multipurpose projects, have enormous flexibility in how they are operated. One of our challenges is to respond to evolving demands and values in the operations of those reservoirs. That in itself is a very complex planning process and in many cases very controversial. For example, now we are reviewing the operation of our Missouri River reservoir system, our largest system, and the regional interest in that is quite notable. There are significant trade-offs involved and everyone awaits COE's analysis as the beginning of the dialogue for choice.

We also administer the Clean Water Act section 404 regulatory program and in that arena work very closely with people who are engaged in watershed planning. Those of you who have participated in advanced identification know that there is much that can be done with the regulatory program to put it in a larger watershed context.

Having made those few observations, let me say a few things about the watershed planning process—points that others may have made but which I believe are well worth repeating because they are often too easily forgotten.

The first is that you must follow a disciplined planning process. You must systematically consider alternatives including scale. Planning is a very complex process. Unless you do it systematically, you won't be able to articulate the rationale for the plan and defend it against critics. Indeed, no matter what the planning process is there will be critics because there are important trade-offs—important societal choices to be made.

Second, you need to relate whatever you are doing in the watershed to a larger context. That may be a basin context, an estuary system, or the economic system. Whatever we are considering, whether it be environmental or economic, we are dealing with complex interactions and we must relate our smaller planning efforts to a larger context.

Third, you must continually involve the public. I think COE has been among the leaders in federal agencies developing the theory and practice of public participation. We are really quite proud of our process because we recognize that unless you do involve the public your plan will not be relevant. In part, COE has been forced to involve the public because of cost-share requirements that there be nonfederal sponsors of projects.

Fourth, you need to involve decision makers. If there is any lesson to be learned from past efforts at comprehensive planning it is that unless you involve the decision makers—the politicians—you have no assurance of implementability. Existing institutions have to be recognized and where there are not adequate institutions

they must be created. In any case, working with existing or newly created institutions requires the political process in the very best sense. These are social choices, they are governmental choices, and they involve politics. Unless you involve the political actors from the beginning, you have missed an opportunity to ensure that your plans will be followed and implemented.

Finally, to the extent that you look for assistance from federal programs you need to understand those programs—understand their requirements and respond to them in your planning process. We are all experiencing very limited resources. Program priorities are very important, and those who respond to those priorities are most likely to receive funding.

Panel Discussion

Addressing Multiple Interests

On the second day of the WATERSHED '93 conference, a panel representing a diversity of interests met to discuss their perspectives about integrated watershed management.

Gail:

The need and potential for reconciling and integrating the various interests concerned about how water and watersheds are managed is central to the very reasons why many of you came to this conference.

With regard to the format of this panel, we are going to try something a little different—rather than present formal remarks from the panelists, we are going to try to create a dialogue among us to highlight the diversity of interests that must be addressed to achieve improvements in how watersheds are managed in this country.

We are going to focus our discussion around three broad questions:

1. What are the priorities for which watersheds should be managed?
2. What are the key issues that need to be resolved if those priorities are to be met?
3. What are the opportunities that our panelists see for addressing these interests and issues?

For each question, we're going to repeat the same sequence. First each of the panelists will give brief introductory thoughts on the question, and then the panel will discuss the question with one another. I will attempt to integrate written questions from the audience into the discussion of each question.

Jerry will speak first. Jerry, from your perspective, what are the priorities for which watersheds should be managed?

Jerry:

As a dairy farmer who is also living within an area that has been carrying out a small watershed project under P.L. 83-566 for 40 years, I have a good idea of what I want to see happen in that watershed and also what we as a town want to see. We want clean, high-quality water for our individual use. We want our land to be productive. We also want fish in the streams, and we want other recreational areas to be available. And we also want industry to thrive in that same watershed.

When it comes to managing watersheds, we need to look at the whole system. Small watersheds can facilitate cooperation because individuals look after each other. We know when something is wrong and can take care of it. Small watersheds give us a chance to operate in the most efficient manner because we're doing it ourselves—there's not somebody else coming in and doing it for us. Conservation districts throughout this country have been operating on a small scale for 50 years, and we think it's a good way to operate.

Neil:

In southern California, we have a lot of people and not enough water. This was true in the early days when our community was settled and remains true today. The five major agencies that manage the resources of the Santa Ana River, which is the largest river in southern California, sued one another for almost 36 years (we pay attor-

The panel moderator was Gail Bingham, President, RESOLVE, Inc. Panel members included:

- Holly Stoerker, Executive Director, Interstate Council on Water Policy and Upper Mississippi River Basin Association, St. Paul, Minnesota
- Gerald (Jerry) Digerness, President and Member, Legislative Advisory Committee, National Association of Conservation Districts; dairy farmer; and Supervisor, Whatcom County Conservation District, Sumas, Washington
- Dale Pontius, Vice President for Conservation Programs, American Rivers, Washington, DC
- Neil Cline, General Manager, Santa Ana Watershed Project Authority, Riverside, California
- Sharon Haines, Ph.D., Manager, Forest Environment, International Paper, Washington, DC

neys by the hour there), and they finally agreed after three decades of litigation to share the meager water supply provided there be some sort of watershed water quality program put together.

Today we have 4 million people who depend on a combination of our local water and imported supply. The imported water constitutes about 60 percent of the water that is used, but is not reliable. Half our water comes from the Colorado River, and in the near term the State of Arizona is going to confiscate about half of that. So we are looking forward to a loss of water from the Colorado River. For the northern California supply, which constitutes the other half of our imported water, we have a contract for about 2 million acre-feet. But, last year the state was able to deliver only about one-tenth of that. With new environmental rules and the continuing battle over water supply, it looks like the best we will get from the state is less than half of that. This puts an emphasis on managing our local supply in an optimal fashion.

The local supply is drawn primarily from ground water that is recharged from the Santa Ana River and its tributaries, but the ground water is threatened by contamination from a hundred years of agricultural activity. Currently, right in the middle of our watershed we have the largest concentration of dairy cattle outside of Holland—about 300,000 head of cattle on 11,000 acres sitting astride the Santa Ana River. Remember that one cow is equivalent to about nine unsewered people, so we have about 2.7 million unsewered functions going on right in the middle of our water.

Our fundamental interest in watershed management is to optimize the available supply to provide successive beneficial use. The competition for water is intense and will continue to intensify. The agencies that fought each other for over 30 years and then formed the organization I work for are about to enter another law suit—not over the fresh natural runoff, but over the sewage that is discharged into the Santa Ana River. So we need water and we need to manage it in a way that will minimize our costs and protect the health and welfare of our people from both a health and an economic standpoint.

Sharon:

From the perspective of forest industry, one of our major needs is water for our facilities. As many of you probably know, paper making uses large quantities of water and in the past we've had a high use of hydroelectricity as a source of power. This has changed somewhat because we now have more cogeneration of power and we've also had some process changes that make more efficient use of water. But, the use of water remains very important to our facilities.

Our larger landowners also have a substantial interest in recreation on their properties so it's extremely important to have clean water for fishing, canoeing, boating, rafting, etc. We also benefit from clean streams and streamside areas that are aesthetically pleasing to the public that uses our lands.

Obviously, another key need for us from a watershed perspective is to be able to manage our forests to supply fiber. We firmly believe that it is possible to do this in a way that meets our needs economically as well as protects environmental quality. One of the advantages of watershed management is that it more nearly reflects the interrelationships that exist among biological systems. This is true in both unmanaged and managed systems. The process of watershed planning may offer us a good opportunity for striking a balance between economics and environment.

Dale:

I am here representing American Rivers, a national conservation organization whose goal is to preserve and restore America's rivers and to foster a river stewardship ethic in this country. In that respect, I guess I am representing the nonconsumptive users of our watersheds. We focus on three basic issues:

- Protect, and where necessary restore, the headwaters. These areas that recharge our systems are for the most part in Federal ownership, so we focus on national policy to protect headwaters.
- Restore and protect the flows of rivers that have been endangered over the years by development practices. The fish and wildlife in our rivers are in jeopardy. As many reports and scientific studies have shown in recent years, the decline in aquatic species is much more rapid than in terrestrial species, so we see a need to protect in-stream flows and biodiversity.
- Restore and protect riparian zones. These areas have been severely

degraded, especially in the western states, and they are key elements in the watershed ecosystem. They filter out contaminants and sediments and provide essential habitats for many species that are river- and watershed-dependent.

If you look at the alarming statistics in recent years, you'll see why organizations like American Rivers exist. The rivers in this country are in serious decline, and we think that the most important role we can play is to see that the river systems are managed and our water policies are reformed to deal with the restoration of biodiversity and to ensure that nonconsumptive uses are considered on an equal footing with consumptive uses.

Holly:

I'd like to answer this question from the perspective of a participant in the management of the upper Mississippi river system. I think my views may be applicable to other large inland river systems in this country. I think it's fair to say that our goal is to sustain the river system for multiple purposes. In the upper Mississippi there are four main areas of concern: water quality; fish and wildlife habitat protection; water-based recreation; and commercial navigation.

To the extent that the watershed approach is comprehensive and holistic and integrated and multiobjective and multipurpose—and—to the extent that it is based on partnerships at different levels of government and among different interests, then I think that the concept has substantial appeal. However, I think our definition of watershed is rather sloppy if indeed that is really all that the concept suggests to us. My impression has always been that the watershed approach had associated with it a landscape component, that is, in addition to all of the process components that I just described, the watershed approach also put these processes in a geographical context.

I would suggest to you that a watershed approach is very conducive to water quality and fish and wildlife protection. On the other hand, I find water-based recreation and commercial navigation far less amenable to a watershed perspective. I don't mean to be the only skeptic at the table, but I think we need to think not only in terms of watersheds but in terms of river systems for issues such as navigation development.

Gail:

Thank you, Holly. Now, before I take the first question from the audience, do any of you have any questions for one another to launch this conversation?

Dale:

Being from Arizona, I harbor a bit of a resentful comment on the stealing of Colorado River water. I should respond that those water rights were won fair and square in the Arizona share of the Colorado River. However, that points out an important water policy issue in the West—the institutional restrictions on the free transfer of water to higher and better uses. Agriculture, as you know, has dominated most of the water use of federal water projects over the years and now we see increasing demands by municipal users and for fish and wildlife needs, but there are still a lot of institutional barriers to transfer that water. Arizona's reclamation project is in serious financial trouble currently. Lots of people, including environmentalists, are starting to talk about the need to free up that water for people in California and using some of the proceeds of that water, if they can be transferred in a water marketing sense, for restoration of streams, for fish and wildlife needs, and to pay off the debt on the Arizona system.

> "our goal is to sustain the river system for multiple purposes."

Gail:

This illustrates the challenge we have. The initial remarks have highlighted some of the priorities for water management, and most believe that watershed management may be a better tool for satisfying more interests—but that doesn't mean the interests aren't in conflict. One of the questions from the audience is pertinent here—"What's different about watershed management that makes us believe that more of these interests could be satisfied?" The flipside of the question might be "What are the barriers today to achieving better in-stream flow, to obtaining the water supply for a growing population, to provide for navigation?"

Dale:

I'll take a shot at some of the barriers. There are institutional barriers in the current system for how we plan for federal land; for

example, different agencies may do different plans, sometimes inconsistent plans, within the same watershed.

There are barriers from past practices. Again referring to the West, as values change toward more recreational uses, toward more habitat conservation and aesthetic uses of our watersheds, it's difficult to find the water to sustain those because it's all spoken for in prior rights. As I said before, we need mechanisms to free up some of the water rights through a market system, through government action, or through local action. And that can probably be most effectively accomplished on a watershed basis.

"Personal responsibility and private property rights are key issues . . . ."

Gail:

Holly, in your work with the Upper Mississippi have you seen any opportunities to deal with institutional barriers?

Holly:

I think our challenge is to invigorate our institutions and create incentives so that people want to manage their water needs on a watershed basis. Many of the sessions I sat in on yesterday dealt with water quality issues. And this panel is broaching other issues, such as water supply. I think that in order to be really effective watershed management will need to incorporate a wide variety of water management issues.

Gail:

Jerry and Sharon, because you indicated in your opening remarks that you are particularly concerned with the way that the land around the water is used, perhaps you would like to respond to this question: "Property owners do not want to be told what they can or cannot do with their land even though cumulatively their activities may affect others. Industries are subject to regulations—why not private property owners, too?"

Jerry:

Well, that's a major issue for people like me who manage their land as a resource. It comes down to the philosophy of watershed efforts. I see that a lot can be accomplished through education. Helping people to understand that what they are doing is important in that watershed. We can't possibly have enough regulators to watch that every person is doing the right thing, but if people feel a duty—if they recognize that they are part of the problem and they play a part in the solution—then I think that we can make some headway.

Sharon:

I think that we should view regulation as a last resort. Regulation is much less economical and equitable than voluntary methods. In terms of land management, in the West the forestry industry is subjected to regulation through state forestry practices acts. In the South, most states do not have formal forestry practices acts. I would hope that there is still the opportunity for enough innovation and cooperation that we do not have to resort to forest practices acts everywhere. Personal responsibility and private property rights are key issues, especially when you are looking at watersheds that encompass a broad number of uses and large number of owners. I believe private landowners clearly have a responsibility to manage the resource properly. Private ownership has to be balanced with public good, and we are struggling with that across the entire country on a range of resource-related issues.

Dale:

I just came back from looking at a situation where private property rights and lack of governmental regulation had a long-term devastating impact on a watershed. Colorado approved a large gold mine (Summitville mine in the San Juan Mountains) 4 or 5 years ago without adequate regulatory oversight. Obviously, people focused on the short-term economic benefits of providing jobs. Now the site is costing taxpayers $33,000 a day because the owner has gone bankrupt and, as a result of poor mining practices, has left a $40 million-$60 million clean-up job. This is an example of land use at its worst in a watershed. I think the largest failure of this country, in terms of the protection of our watersheds, has been the lack of adequate land use regulations at the local level and at the federal level.

Gail:

We have already begun to answer our second question, but let me state it now: "Given the different priorities for beneficial uses in our watersheds, what are the issues that need to be resolved in order to make

progress?" Obviously, some interests and concerns are more compatible and others more challenging to resolve. I'd like to step back and ask our panelists, from their perspectives, what issues will be the most challenging to resolve.

Holly:

I see five major issues.

The first is scale. Most of the success stories I heard about in yesterday's conference sessions, from my perspective, were relating experiences of watershed management on a small scale. When you think about the upper Mississippi basin, we're talking about 120 million acres of land, a huge chunk of the United States. The second issue, which is related to scale, is defining units of analysis. We need to have units of analysis that can incorporate economic and other interest "trade-offs" in meaningful ways.

The third issue is a nasty one—hydrologic versus political boundaries. That is a fundamental incongruity that seems to have plagued the watershed approach for some time. Again, I think it is partially linked to questions of scale (as you get larger you have more institutions to deal with), but I think there are some other complexities. In the upper Mississippi, for example, the river not only defines the watershed but is a state border so the river is an edge of a political jurisdiction and not at the center of what the people think of as their sovereign domain.

The fourth issue is the linkage between planning and management. When you start to move to the real challenge of implementation, you encounter a host of knotty problems linked with the dilemma found between hydrologic and political boundaries.

That reminds me of the discussion of scale vis a vis planning and management functions in the Water Quality 2000 report. Water Quality 2000 recommends a nested hierarchy approach to watershed management in the country and points out that larger-scale watershed efforts would carry out relatively more planning functions than implementation, whereas the smaller watershed efforts nested within larger ones would emphasize implementation. That seemed intuitively attractive to me, yet the more I thought about it the more I wondered whether it defies what we claim to be the success of the watershed approach—that it is locally based.

Dale:

We're all struggling to try to define the management unit, and I think it varies from place to place. There are definitely areas that need large-scale watershed management. For example, the Virgin River watershed includes land in three states. The water has not yet been allocated among those states. Different divisions within each federal resource agency have responsibility for different parts of the watershed. If you look at the Rio Grande, you're not only talking about Colorado, New Mexico, and Texas but also Mexico. There are enormous problems along the border with impacts on human health resulting from using the river as a waste disposal system. Clearly, these situations suggest a need for some sort of interstate and international compacts.

> "the lack of effective land use controls aggravates our watershed problems . . . ."

As we look for models, people talk about the Northwest Power Planning Council as a model for large-scale watershed management (Columbia and Snake Rivers). But that entity, as I understand it, is pretty much in gridlock over resolving the tough questions because it is part of the political process.

So, that is one of the key questions if we think watershed management is the way to go. It's easy to tell the federal agencies to manage their lands on a watershed basis, and that can probably be accomplished if it becomes national policy. But when you go beyond federal lands, it is very difficult to define the proper management unit.

Again, I think the lack of effective land use controls aggravates our watershed problems and will have to be dealt with sooner or later in this country—carried out at the local level with encouragement from the federal government.

Sharon:

My list includes a number of issues already mentioned—the scope or extent of the watershed, the scale at which actions are to be taken, the level at which decisions are to be made, and the level at which accountability comes into play. We've already talked about the balance between private property rights and public good—responsible management. An equitable balance

among all of the uses that are legitimate within watersheds is another key issue that needs to be resolved, and the resolution will not be the same in every watershed.

One of the things that concerns me most is that many people perceive that watersheds have to be left undisturbed in order to provide good-quality water in adequate quantities. Properly managed forests can also provide adequate, high quality water. Anyone who owns large tracts of forest lands will feel threatened if they are considered to be the solution to the problem and their options are limited. We need to avoid jumping to regulation; we need time for innovation to work.

> "There must be a way—through education, action or example—that we can begin to trust one another . . . ."

Nell:

I think the issues are scale and control, money and trust.

Everyone has discussed scale so I won't elaborate on that too much. I do feel, though, that in order to be effective—to initiate a national policy—we should think small, not large. But it comes down to a matter of control. In organizing any kind of a watershed management activity, ultimately somebody has to be in control. There is a traditional conflict between political control and technical control. We who are in the water business feel that water is too important—we ought to keep the politicians out of it. That isn't necessarily celebrated by the political elements in our community. But water is a technical issue—water supply, water treatment, water collection, water protection—these are all technical matters and frequently they are inconsistent with political agendas. So there is this push and tug that makes water management a real challenge. Better, more comprehensive watershed management requires the creation of new institutions or methods to integrate existing institutions, and that won't be easy.

Another massive challenge is money. To begin watershed management you have to define the problems, and to begin to study the problems you need resources. Then you need to pay for any mitigation or implementation of the plan that is derived. That may require reallocation of resources.

Another challenge is trust. We do have the resources and intellect to resolve these problems, but we don't always trust each other. There must be a way—through education, action, or example—that we can begin to trust one another because if we don't trust each other we'll never get there. Watershed management will require a commitment from government agencies, from landowners, and from the taxpayers we all serve that we agree to work together in a watershed unit. It makes sense. Psychologically, humans tend to gather around watersheds. All the great cities of the world began on a river somewhere, and typically the people shared the river but didn't like the people on the other side of the hill. We need to find a way that we can work with our neighbors.

Jerry:

I think the major issue is education. We spend a lot of time worrying about whether there is money to do things, but I think a lot can be done if we just bite the bullet and start forward. People need to know how the activities associated with raising livestock and crops can affect water quality. People need to know what happens when they put too much fertilizer on the lawn or dump a little oil or antifreeze on the ground or down the storm drain.

We need to consider all the activities in a watershed and plan for total resource management. Rather than arguing over who's to blame, we need to give everyone a chance to be part of the solution.

Gail:

Thank you.

The challenges that we've highlighted so far are process issues. I'd like to play devil's advocate for a minute. My whole career is based on the assumption that people can work together and resolve differences. I'd like to get you to address the tough substantive issues—the real conflicts that create stalemate.

Dale, you mentioned the attempt to reconcile interests in the Columbia/Snake system. Separating out the process difficulties that you already identified, what are the tough substantive issues that need to be resolved in that situation?

Dale:

Well, in the Columbia/Snake system over 100 salmon stocks are seriously threatened and more than that are already extinct. Salmon is a cultural part of the Northwest, a way of life for all people who

live there. There is very strong public support for protecting and restoring the salmon, but there doesn't seem to be an institutional ability to deliver. It is complicated by the system of dams that were built, without the salmon in mind, for the purpose of supplying power. People rely on that cheap power, and politicians have to make tough decisions about raising rates to pay for water releases to support the salmon. Despite polls that indicate that the public is willing to pay the price, politicians are typically unwilling to make those decisions. People at the local level have to buy into what they want for the watershed—the values that they want to protect. Then, you can get political support but you still need an institution that is responsive.

Gail:

Holly, we have a question from the audience for you: "Commercial barge traffic, maintenance, and proposed improvements to the navigational channel of the Mississippi River system have severe impacts on backwater and other habitats. Given that adequate alternative transportation systems exist on land, how do you view the compatibility of navigational and other uses of the river?"

Holly:

The fundamental dilemma on the river system, for as long as I've been associated with it, is navigation and fish and wildlife habitat. There are definitely impacts of navigation on the environmental integrity of the system. I think there is compatibility—in fact, there are real opportunities to creatively manage the system for dual purposes. I think we frame the question in the wrong way, a way that is not conducive to coming up with solutions that will be mutually satisfying. In other words, if we simply think of the problem as the impact of navigation on habitat, then we have neglected to think in terms of operations that might be altered to support both navigation and fish and wildlife.

Gail:

That's an important point. One of the principles of integrating interests in conflict resolution is to ask ourselves whether we've asked the question in the most productive way—whether reframing the question will open up opportunities.

Sharon:

Holly, how do the impacts of increased navigation compare to the impacts of increased use of terrestrial transportation systems?

Holly:

You can look at it in lots of ways. But if you consider one kind of environmental impact, such as spills, you find that the railroad corridors still leave the river very vulnerable because the rails parallel the river to a large extent. You can also look at it from a multimedia viewpoint; for example, air pollution from truck traffic. Again, this brings into the question the use of the watershed as a unit of analysis when considering transportation trade-offs.

> "we need to give everyone a chance to be part of the solution."

Gail:

On an different issue, Neil, would you like to answer this question from the audience? "The panel has focused on surface waters, at least implicitly, and the role of ground water and its protection has been overlooked, as it often is in watershed discussions. Shouldn't there be a priority for restrictive land uses over ground water recharge zones?" There are obviously some competing concerns there.

Neil:

Ground water is an extremely important component of our nation's water supply and it must be protected. In southern California we seem to be fighting an uphill battle. The agricultural producers that worked the land before it was heavily urbanized used a lot of fertilizers, so we now have nitrates that are working their way to our ground water supply. A recent study revealed that, by employing a ground water recovery method that desalts or demineralizes impaired ground water, the Metropolitan Water District will have access to about 200,000 acre-feet annually, about 10 percent of the water supply for southern California. Had we recognized the threat posed by human activities earlier, we probably would have managed our land a little better.

If I may add a thought about setting national policy, the danger as I see it is that very well-intended national policy can go awry and create dreadful problems for local

operators. I'd like to give an example—share the misery with you—if I might. Historically, the Santa Ana is an intermittent stream. During periods of heavy rain, water flows quickly from the mountains to the sea, and during the summer there is significant percolation to the subsurface and the stream comes to the surface in different locations. As our communities have developed, more and more cities return water to the river, including some that never came from the Santa Ana, so now we have a perennial stream composed of treated sewage effluent. The national regulations on water quality for a perennial stream require us to bring the Santa Ana to the quality required for a trout stream. It never was a trout stream, but by national standards we have to convert it to a trout stream except for temperature. Well, our local sewage treatment plant operators look at this policy and say it is way too expensive. We would have to treat our water extensively and put it back in the river. There wouldn't be any trout in it, but the people downstream would get very high quality water at our expense. So we're not going to do that. We're going to divert our water someplace else. It's cheaper for us to pump water for agricultural uses or out into the desert for other uses. In terms of watershed management that is exactly the opposite of what you want to happen because people downstream rely on the water supply being there. So any national policy has to take into consideration regional differences.

> "We need to spend more money on water if we are going to continue to provide the service that people expect."

Dale:

I agree with Neil.

Sharon:

I agree, too. Some of our facilities are required to discharge water that is cleaner than the water we started with, and we don't get any credit for that.

Dale:

I'd just like to add a thought about ground water. There is a need to address ground water as part of the basin and account for the hydrological connections between ground water and surface water. Especially in the West, we have lost streams and cienegas due to overpumping. The need to protect riparian zones for recharge purposes and the need to protect ground water from contamination, because of the tremendous cost to clean it up, are real.

Gail:

That's a nice segue into a question that has come up in many forms: How do we pay for watershed management? How much? What are the mechanisms, for example user fees?

Neil:

Excuse me for speaking very parochially, but in southern California the average person's attitude about water is that it comes from under the house. And they expect it to be in copious quantities, of high quality, and at no cost. This is a real problem. The water in southern California is inexpensive. We need to spend more money on water if we are going to continue to provide the service that people expect. The Metropolitan Water District of Southern California will likely double water rates in the next 10 years. There is immense political resistance to increasing rates, as you might expect. On the other hand, when you compare typical household water bills to monthly cable TV bills, you find water is less expensive. So, over the next decade or so, we need a change in public priority.

Holly:

I would like to throw out a general (and maybe fallacious) assumption that I operate under when I think about watershed management, and that is that much of our investment is an up-front investment in better development of data systems and enhancing our understanding of watershed dynamics. Many of the implementation functions will use techniques that are less expensive than some of the measures that we have already put in place; for example, point source treatment plants.

Dale:

I agree that water is too cheap and people have had it too easy for too long. In the West, in particular, we have subsidized water so in reality people live on cheap water at the expense of federal taxpayers.

There are two ways to address this. One is to put a surcharge on water to bring it closer to market value. This would require educating people about the real costs of

water—you have to internalize the cost to the environment to the production of the resource and to the maintenance of it for the future.

Another way is to open up markets. Agricultural producers have extremely low cost water that they could sell to municipalities. This would bring water up to its market price, diminish the need for new water projects, and encourage conservation. People would profit from it, and so would the environment.

Hydropower is another subsidized use of the river. Hydropower projects that are up for relicensing over the next 30 years produce power worth $10 billion using public resources, the river, for free. That should be taxed. Owners of dams should pay for the use of rivers, and the money derived should be used for environmental protection.

Jerry:

Sometimes we make political decisions on perceived notions. Here's a good example concerning water rights from my home watershed. Under a proposed law, people would have to use their wells at least once every 5 years. So, we have people who are pumping water onto saturated ground just to protect their well rights. We need to prevent these misperceptions. We need to avoid passing laws that do not work at the local level, and that is why I feel strongly that we need to empower the local level to make judgment calls and use our resources wisely.

Sharon:

I want to make two points.

First, we do not learn from each other. For example, in the extensively farmed area of south Georgia, where I live, people believe that ground water is an inexhaustible resource. They have not listened to what has happened in other areas. They do not understand the dire consequences of poorly managing ground water.

Second, there is a lot of research that is providing us information on cumulative effects and other processes that are functioning within water systems. We have to find a better way to communicate—to more quickly apply new data in the decision-making process.

Gail:

Several people in the audience are asking about the specific tools to make voluntary actions effective and also the limits to voluntary action—in other words, what problems can't be solved through voluntary action.

Sharon:

The forestry industry has been involved in the development of best management practices that allow us to use the land while protecting the water. In some cases these have been codified in forest practices acts, but in other places they remain voluntary. I think this is one of the contributions that forestry has to make to the entire process of watershed planning. We need to remember that best management practices are not a "one-shot" deal, but are an iterative process: as you learn, you modify your practices. We should have the opportunity to make a voluntary process work before moving to legislation. But, if you give me the opportunity to do it right voluntarily and I don't measure up, then regulations are warranted.

"We should have the opportunity to make a voluntary process work before moving to legislation."

Gail:

Our third general question is "What opportunities do each of you see to successfully address these issues, and what contributions can each of your organizations make to those solutions?" But someone in the audience phrased it this way: "Would each of you rephrase your opening remarks in order to cast the potentially opposing interests as not being between current uses and needs, but rather how water is being managed today and how we want to be able to use water in the future?"

Holly:

I would like to refer to the remarks that Warren Fairchild made in the opening session when he invited us to revisit P.L. 89-80, The Water Resources Planning Act. It was 1965, when we had the Water Resources Council (WRC) and River Basin Commissions. I think there are concepts from that act that we may want to resurrect, even if we don't want to resurrect an institution.

There are two concepts that I took away from Warren's remarks. First, we

could create a system for coordinating national water policy separate from any federal agency (like WRC). Presently, I see a danger with having federal agencies jump on the watershed bandwagon and having each define what watershed management means to them in ways that are useful to their own missions and purposes, so that we lose a more holistic federal perspective. We need to be able to define what the federal perspective is in watersheds. Perhaps that doesn't mean we need to reconstruct WRC, but I would like to think that there is a way that the federal government could get its house in order.

Second is the concept of River Basin Commissions. There is an opportunity to build on what we have. Those Basin Commissions were officially terminated in 1982, but they didn't just whither away and die. They went through a metamorphosis—they changed their function, mission, and composition. In many regions of this country, people struggled to keep some remnants of those institutions alive because they saw utility in being able to think on a regional and watershed scale.

My suggestion would be to revisit some of those ideas and learn from them.

Nell:

This is obviously a very complicated institutional issue. The fact that there are about 1,200 people at this conference from many different kinds of organizations shows that watershed management is an important concern for many people, and we want to learn from each other. I think that this is positive—that some progress is possible. Therefore, we need to have more gatherings of this type so that we can find better ways to work together.

We think that we have a rather successful water management process on the Santa Ana River. As I mentioned, this is organized by people who sued each other for about 36 years (and they are about to sue each other again, this time with a smile). The key has been regional planning on a fairly manageable scale (there are 2,800 square miles within the watershed) controlled by local interests that make a commitment with one another to cooperate. I'm not sure if our situation could be modeled on a national basis.

Within the State of California, we have a very effective and efficient way of monitoring water quality control. The State is divided into nine regions, each developing a regional approach with local control. We sometimes struggle with big issues, but we have a process and it seems effective.

I believe that whatever institutional evolution might occur, it should not be organized like EPA. EPA does many wonderful things, but if you have trouble with EPA, there is no public body, board of directors, or process to help you. You're dealing with a staff that can become amorphous, which becomes very difficult for the local operators. If there is a public body that you can go to, to which this new agency or even EPA is accountable, it would be much more effective because you would have two-way dialogue. It would eliminate the system of policies being made somewhere, never where you are, by the federal government — policies which become law that you are told by some functionary to follow.

In the State of California, when you have difficulty with the Water Quality Control Board, you can talk to their board of directors, who are selected from a cross section of the public. If you don't like their decisions, you can appeal to the state board, which is also a public body. So the institution has an exchange of ideas with the people who have to abide by the regulations. Perhaps our country is too vast to implement that type of mechanism, but I believe we need to institute some type of process like that. I don't mean to knock EPA. They have their job and they do it very well. But, if I do disagree with their policies, then it's "lights out." I think that's why there is this fear that if we get some kind of ground water regulation or national watershed regulation, that there's going to be somebody from the outside telling you how to solve your problem. People don't like that.

Jerry:

There is a tremendous opportunity to move forward. But everybody needs to be involved—from Washington, DC, down to my dairy farm in the State of Washington. Our organization, the National Association of Conservation Districts, through our Conservation, Information and Technology Center, was recently involved in organizing "Know Your Watershed."

Our goal is to take this process right down to the local level, and we want to build alliances with a number of organizations. Our goal is to reach and inspire every individual land occupier—from apartment

dwellers in the city, to suburban families, to farmers. We can bring a lot of energy and talent to this campaign to protect our watersheds, and I would like to invite the panel and the audience to be a part of this campaign. I think we can have some very positive results.

Sharon:

Coming from the forestry perspective, I think one of the things that we have to bring to watershed planning is the fact that our business is a long-term business. We're used to planning on a long time frame, which is important as far as watershed planning is concerned. We're used to dealing with things on a large scale. We're the source of clean water. We have good experience in best management practices in terms of development, implementation, and revision as new information becomes available.

It's important to realize that it's going to take time to develop an equitable solution, especially when you consider the diversity of viewpoints that we've covered today and are apparent in any given watershed. We've already heard about the need for dialogue and building trust. As a veteran of a recent consensus-building exercise, I can tell you that it takes some time to develop that trust. You have to give everybody the opportunity to have their say and begin to see what's in it for everyone before you can even begin to think about developing an effective consensus. In my mind, consensus is not a dirty word; it's not compromise. Consensus is creative solutions as far as I'm concerned.

It is also critical for us to identify the success stories. We must ask ourselves: "What are the successful models that worked someplace, and why did they work?" We must publicize those techniques to the point where the successful ones can be extrapolated to other circumstances and used. The same thing obviously doesn't necessarily work in different places, but if we publicize things that work in some area, variations of that may be useful elsewhere.

Dale:

I think that there are some bright spots in the future, some of which the new administration has exposed. I'm hopeful that the forest meeting in the Northwest in a few weeks will produce some kind of consensus. I have my doubts, but it is good to bring people together to resolve some differences. I think the administration's approach with respect to ecological planning and biological surveying of our resources is an excellent start toward this kind of movement.

We need to move forward (in a watershed sense). It's important because we have stressed our watersheds to the point where we all recognize that we can't keep doing this. We can't keep using them as waste conduits. We can't keep adding people and pressures on the resource. Therefore, there must be planning and commonly shared goals regarding how we are going to live on a particular watershed as far as what we're going to develop and what the objectives are.

I was in the Rio Grande watershed recently, and I found it interesting that three or four different groups have come from different areas trying to solve this problem. I assume that eventually they will get together to talk about elements of that watershed and what needs to be done. There is a group in the middle part of the Rio Grande dealing with what to do about the future biological integrity and management of the Bosque along the river for about 150 miles. These are people concerned about the entire watershed from an academic and biological perspective. People are starting to form committees and groups to address these problems. Hopefully, it will get beyond the think-tank stage.

As an organization, I think we have to think about the current discussions of new policies and try to promote some of the things that we have discussed. Focusing on biological surveys and watersheds is a good place to start because that's really where all of the biological treasures are located. The Clean Water Act, to focus on biological criteria of watersheds, has not been mentioned much in the past but is very important. Mining law reform is an essential ingredient for watershed protection in the future. In terms of headwaters of watersheds, the Wild and Scenic River System, which is 25 years old, could be doubled with any kind of congressional effort in the next 2-4 years. There are many rivers out there that are eligible for designation as Wild and Scenic Rivers. So those are a few ideas.

Gail:

Thank you.

One of my jobs as moderator is to manage time, and we need to finish up now. But, I would say that we received more than

Additional Questions from the Audience

- Do you feel that our knowledge of watershed science and watershed processes is well enough understood, or do we need more emphasis on defining watershed processes?
- It is suggested that private responsible behavior is superior to regulation, which should be viewed as a "last resort." What tools does the panel foresee to induce responsible behavior?
- What can be done to educate state and local leaders about the importance of watershed-based planning?
- Is it truly possible to make progress on addressing multiple interests in a watershed context until our governmental systems are structured in a similar way?
- Can we have a sustainable plan for watershed management without addressing population growth? If not, how can government agencies and private organizations change human population levels and trends?
- Since the environment is the source of all economies, the choice between a strong economy and a clean environment is a false choice. How can watershed management be used to sustain economies and the environment?
- Can effective watershed management be achieved within the current bounds of federal law?
- Are multiple programs within a watershed an impediment to holistic watershed management? How do we deal with this?
- What role should water conservation play in watershed management?
- Given modern information management and communications technology, is it necessary to choose any *one* scale, unit, or perspective of watershed management? Can we accommodate multiple perspectives to find and implement sound solutions to problems?

100 questions from the audience and have only been able to respond to a few. Many of these questions are on the leading edge, trying to find opportunities to solve some of the most intractable problems we find in watershed management.

Maybe the best way to conclude this panel is to hold a mirror back up to you—to ask you to reflect upon some of the questions over the course of the conference and as you return to your regular work. Here are some of the broad issues that were raised:

- Nonpoint source pollution—the challenges and opportunities for addressing it through a watershed approach.
- Roles of the public and private sectors at the local, state, and federal level.
- Scale—do we need consistent definitions of hydrologic units for planning purposes?
- Population growth.
- Land use.

Obviously, some of you, the conference participants, had the wisdom to ask these questions. Now, it's our responsibility to work together to answer them.

Thank you all.

Remarks

Diversity of Approaches in Watershed Management

Cynthia J. Burbank, Chief of the Environment Analysis Division
Federal Highway Administration, Washington, DC

I appreciate this opportunity to tell you a little bit about the Federal Highway Administration and its role in watershed management. We are one of the sponsors of this important conference, and yet, if you look at a list of the sponsors, we are a little different. Unlike many of the others, we do not directly sponsor watershed management or protection programs. However, we do have a strong interest in this area. And I think it is very appropriate that we serve as a bridge, if you will, between the earlier panel on the diversity of interests in watershed management and the next panel on diversity of approaches because we represent one of those diverse interests and pursue some of those diverse approaches.

The Highway Administration's raison d'etre, of course, is ensuring that this country has effective and efficient transportation to serve the economic and social needs of the Nation. Together with our sister agency, the Federal Transit Administration, we administer a $150 billion program of assistance to states and metropolitan areas to build and, increasingly, to operate transportation systems.

Over the past 20 years, the linkage of our program to the environment has grown stronger as people have become more aware of the impact of transportation decisions and operations on the environment, as well as the importance of building environmental sensitivity into the construction, management, and operation of transportation systems.

Our interests include everything from ensuring that new highways avoid or minimize impacts on wetlands, to controlling water runoff from highways, to looking at the linkage between land development and transportation and trying to figure out which is the chicken and which is the egg—still an issue of research and debate.

Over the 20 years that our environmental awareness has grown, we have realized that our responsibilities go beyond the two "e's" of efficiency and effectiveness of transportation to environmental compatibility, protection, and, indeed, enhancement.

Just over a year ago new legislation was enacted for federal surface transportation programs, which provides the $150 billion that I mentioned earlier. Certainly, this is a substantial amount of money, so when we talk about the greening of the Federal Highway Administration we are talking not only about the growing environmental philosophy but also the growing funding not only for transportation but for environmental protection. Our funding programs now have much greater eligibility for wetlands protection, wetlands planning management activities.

Not only do we bring to this conference an interest in environmental protection in carrying out our mission and greater eligibility of funds to carry out watershed planning and management, we also bring experience in comprehensive, holistic planning. We call it the "three C process" for comprehensive, continuing, and cooperative planning. We have been using it for more than two decades for multiobjective transportation-related planning in communities around the Nation. Many of the issues are the same as those you have been talking about for watershed management. For example, it involves reaching around

political boundaries to more functional boundaries, involving decision makers and citizens in the process, creating or shaping institutional champions for more comprehensive planning, and finally, it involves embracing and balancing multiple objectives.

I can't say that there are any secrets to success. I can say that comprehensive planning takes a certain stubbornness—to keep at it in the face of many challenges. It particularly requires an insistence on keeping the various parties talking to each other and working together, not letting them leave the table. And, as Mr. Dickey said this morning, it takes a lot of discipline.

It is our privilege to be one of the sponsoring agencies today, and I hope we'll be able to contribute in the future to the further evolution of watershed management and to be part of the process of making comprehensive watershed management real.

Bear Creek and the Origins of TVA's Clean Water Initiative

Ralph H. Brooks, Ph.D., Vice President, Water Management
Tennessee Valley Authority, Knoxville, TN

If you heard Tennessee Valley Authority's (TVA) Chairman, John Waters, speak yesterday at the opening session, you know that TVA is working on a new model for watershed management. We call it our Clean Water Initiative, and we're convinced that it will provide the framework that our region needs to turn the Tennessee River into the cleanest, most productive commercial river system in the Nation by the year 2000.

Why are we so confident? Because we've experimented with a lot of different approaches to river cleanup, and we've found one that really works. It works because it includes two key elements: increased public awareness of water resource problems and cooperative problem-solving.

If I had to pick one project that shaped our Clean Water Initiative more than any other, I would choose a project that began in 1985 when Congress provided funding for TVA to restore water quality in the Bear Creek Floatway in northwest Alabama. The river below Bear Creek Dam flows through a beautiful gorge and offers whitewater rapids that attract rafters and canoeists from a wide area. But in 1984 the floatway was closed to recreational use because of high fecal coliform concentrations. Aerial photographs and targeted monitoring showed that the main problem was lack of adequate animal waste management on many small farms.

The rest of the story is a prime example of how agencies and individuals can work together to preserve the quality of our natural resources for future generations. I'd like to show you a short videotape so that you can hear about the project firsthand from our project partners. Then I want to talk a little bit about some of the lessons we learned, and how we're applying them in our Clean Water Initiative.

The Bear Creek Floatway—A Story of Renewal
(Transcript)

From high over the textured landscape of northwest Alabama, you can see where Bear Creek begins. It flows northwest through Marion and Franklin counties for more than 40 miles. It then turns north, is joined by Cedar and Little Bear Creeks, and empties into the Tennessee River. For generations, there have been many stories about Bear Creek. And no wonder. In places, sheer cliffs create a feeling of cool remoteness and mysterious gloom. In others, the creek is open to the sky and warm and inviting sunlight dances on the water.

Only recently has the natural and uncommon beauty of Bear Creek been seen by many more people than only those living nearby. In the 1970s, TVA built four earth dams—one each on Cedar and Little Bear Creeks and two on Big Bear. Their purpose was to provide for flood control, to create dependable water supplies for nearby communities, and to open up new opportunities for recreation. Besides new areas for camping and picnicking, the project included development of a 25-mile floatway between the two dams on Big Bear Creek. Water could be stored during heavy spring rains, then released throughout the summer to make

the creek much safer and suitable for floating. This part of the creek provided canoeists with some of the best and most challenging water in the mid-South.

But just as people were beginning to discover and to fully enjoy the floatway, surveys revealed that the water was heavily contaminated with fecal coliform bacteria. Frustrated officials posted signs warning people that the water was unsafe, and disappointed boaters were turned away. The part of Bear Creek that had promised so much was closed indefinitely. By 1985, sampling plus aerial photography, which has become extremely useful in similar situations, had identified livestock on farms as being the main source of the bacteria. Although some of the livestock were being kept directly on the creek, most of the contamination was originating in dozens of hollows and along many very small streams in the Bear Creek watershed. Further surveys revealed some surprising and sobering statistics. Each year, hog, poultry, and cattle operations were creating about 40,000 tons of manure. That's equal to the same pollution load produced by a city of 15,000 people. Much of it was draining into Bear Creek.

Identifying the problem was one thing. But solving it was quite another. Many farmers, already under economic stress, either didn't have the money to make needed changes or didn't want to change management methods that seemed to work well for them.

One of the farmers most affected was Dale Baker:

"Got a letter from somebody, some government official, . . . wanting all the farmers or people that was on the creek to meet at the college to discuss the pollution on the creek. So naturally I went. I went with the intentions of doing what I could to get on to the fellows doing the polluting as strong as I could. I know that I don't have much influence, but I think I could put my two cents worth in anyway. I got up there and found out I was the one doing it. I wanted the creek cleaned up and it was to my benefit. So I agreed to quit half of my hog operation. I quit my finishing process and agreed to just sell feeder pigs if they would help me build this farrowing house that's behind us here for that purpose. It works real good. My children is all gone from home. It's just me and this farrowing house is all I can handle and it don't help me all that much with the number of pigs per sow but it helps a tremendous lot with labor. It is only a fourth of the labor it would be compared to the way I was doing it before."

As more farmers learned of the problem, they were increasingly willing to do what they could to make Bear Creek fulfill its potential. After all, an important part of the local economy was at stake. And that affected everyone. Even more important, the Soil Conservation Service and the Agricultural Stabilization and Conservation Service joined with TVA in a cost-sharing program to help landowners pay for installing animal waste management systems.

About 130 farms were identified as having livestock that were creating waste problems. About half of those farms were responsible for most of the waste. Those were the ones targeted for needing the most help in installing waste management systems. Each system was specifically designed to meet the needs of the particular farm. On some farms, that meant building confinement housing and waste treatment lagoons. On others, feedlots and grazing areas were relocated so that runoff would be filtered and purified naturally in vegetated areas rather than running into streams. Regardless of what methods and systems were used, the goal was the same—to efficiently isolate livestock and their waste from ponds and streams.

The waste management systems installed to reduce contamination of Bear Creek cost $1.2 million, and the results are very impressive. The amount of waste entering Bear Creek from treated farms has been reduced by 20,000 tons per year. Water quality has been restored, and the cost was only about one-fifth of what would have been required to treat the same amount of municipal or industrial waste. Yet, all of this has been accomplished not with chemicals but by simply providing ways for nature to cleanse and purify.

This experience also has emphasized again that prevention is the wisest and far less expensive option. Once again, Bear Creek is a recreational and economic asset. That's possible only because of planning, hard work, and sacrifices by everyone involved.

The story of Bear Creek is one of renewal—a story of what has and remains to be done to protect a small but very special bit of America's natural heritage.

(End of transcript)

As far as we know, this was the first time that a stream, closed because of bacterial contamination, has been reopened to recreation following successful cleanup of nonpoint source pollution. We learned a lot from the Bear Creek experience, and we're beginning to apply these lessons on a larger scale, working with an entire watershed at once, as part of our Clean Water Initiative.

One thing that was very clear in cleaning up the Bear Creek Floatway was the effectiveness of a watershed approach.

The quality of water resources primarily is affected by human activities on the land that drains into each stream, river, and lake. And often the most significant problems are nonpoint sources of pollution. This certainly was true on Bear Creek.

So, as part of our Clean Water Initiative, we are assigning river action teams to work in each of the 12 major watersheds that drain into the Tennessee River. A river action team is a group of TVA experts in environmental science and engineering and other disciplines who work with others in the watershed to protect the ecological health and maintain appropriate human uses of Valley water resources. Their job is to identify the root causes of water resource problems and bring together the people and organizations necessary to find solutions and carry them out.

Another lesson from the Bear Creek project is that it takes more than monitoring to determine water management needs.

Monitoring is important, which is why we've developed the most comprehensive, long-term water quality monitoring program in the Nation. TVA scientists now monitor conditions at key locations on most of the 35 lakes in the Tennessee River system and on major streams. Our monitoring program combines conventional water quality monitoring and ecological monitoring. We keep tabs on a broad range of physical and chemical variables in sediments, fish, and water. And we monitor the organisms that live in the water. These organisms provide clues that can help identify chronic low levels of pollution or intermittent pollution episodes that otherwise might not be detected.

But, in addition to monitoring the water's ecological health, you also need a complete inventory of pollution sources. Aerial photographs of the Bear Creek watershed transformed a dispersed, areawide concern into a defined, site-specific problem. More importantly, the aerial inventory made it possible to target those operations suspected of having the greatest impact on water quality. There were many pollution sources impacting the Bear Creek Floatway. But the ones addressed were those sources that were directly related to the project's objective—reducing fecal coliform contamination.

The list of problems, issues, and needs in a watershed is potentially endless. So, instead of looking at everything, our new river action teams will work with our project partners to set priorities and develop corrective actions that reflect the value of the resource, the severity of the impact on the resource, and the probability of solving the problem.

Another important lesson from our Bear Creek experience is that controlling nonpoint source pollution depends on cooperative partnerships and public support.

It took a cooperative effort to clean up the Bear Creek Floatway. TVA provided expertise in water quality monitoring, aerial photo analyses, and targeting priority sites. The Soil Conservation Service provided expertise in working with livestock operators to design and install the waste management facilities. The Agricultural Stabilization and Conservation Service provided expertise in developing contracts with the operators, and arranging for payment of cost-share monies. The Bear Creek Floatway Advisory Committee provided the guidance for educating the operators and inspecting installed systems. And, finally, the participation of the landowners was needed to ensure the pollution sources would be cleaned up and maintained.

At the front end of the project, the cooperating agencies realized that the education of the polluters, the public, and local leaders was important to gain support and participation. As you heard on the tape, many of the polluters did not realize that they were contributing to the nonpoint source problem. This was addressed through individual meetings with local farmers, and by distributing pamphlets on nonpoint source pollution—what causes it and how to fix it.

We have taken this lesson to heart in our Clean Water Initiative. We are convinced that our success will depend, more than anything else, on our ability to build

partnerships. The top priority for river action teams will be getting agencies, communities, leaders, and the public to work together to find and carry out solutions to river clean-up problems.

The first step is to improve the communication of information about the health and problems in the watershed. That is why TVA publishes *RiverPulse,* an annual report on conditions in the Tennessee River system. *RiverPulse* takes our monitoring results and tells river system users what they want to know: Where is it safe to swim? Are the fish safe to eat? Are conditions adequate for aquatic life?

We published the first issue of *RiverPulse* last summer. It was a milestone for us because it was the first time complex, technical information about TVA lakes has been presented in a format that is easy to read and understand. *RiverPulse* is important because it helps people who are interested in water quality set river clean-up goals and track progress toward meeting them. If we want river system users and the public to get involved in river cleanup, we've got to make sure that they know what the problems are.

We know from Bear Creek that it also helps to offer incentives to encourage people to participate.

The offer of cost-sharing assistance clearly made a difference in the number of landowners willing to install animal waste management systems. Financing pollution cleanup, however, is the responsibility of all partners. TVA will provide financial assistance if necessary, as we did in the Bear Creek project. But the key accomplishment of river action team members is to persuade the public and project partners that solving the river clean-up problem in their area is important to meeting their own economic, social, and environmental needs, and the needs of the community in which they live.

Finally, we learned from Bear Creek that follow-up is essential to the long-term success of a nonpoint source program.

To maintain restored water quality in the Bear Creek Floatway, we helped to implement a program to provide follow-up inspections on installed systems, operation and maintenance training, and troubleshooting for potential problems. We also recognize the need for a program to ensure adequate pollution control for future growth and development.

This is an important point. It will take patience and a long-term commitment to establish the partnerships we need to clean up the Tennessee River. But, in my view, it is the only way we can get the job done. TVA alone doesn't have the workforce or funds to carry out all the needed improvements. Nor do we have any regulatory authority over water users in terms of setting pollutant limits or enforcing standards for discharges. That is up to the individual Valley states. Besides, many of the remaining pollution problems aren't regulated.

That is why our Clean Water Initiative emphasizes communication, education, and coalition building. Time will be required for these efforts to produce the results we desire—the cleanup of the river, section by section. But the solutions developed this way will have staying power because they will be based on common understanding and lasting relationships.

Thank you.

The Chesapeake Bay: A Case Study in Watershed Management

Ann Pesiri Swanson, Executive Director
Chesapeake Bay Commission, Annapolis, MD

First and foremost, I would like to thank you for this opportunity to provide you with an overview of our approaches to restoring Chesapeake Bay. As the executive director of the Chesapeake Bay Commission, I am often asked to travel to faraway places and explain how we have "done it": How have we coordinated such a massive clean-up program, and how have we measured our success? In my brief time before you this morning, I'd like to give you a feeling for just how this massive program of ours works and an overview of some of the lessons that we have learned.

I had hoped to begin my presentation with slides. However, with three general assemblies in session and the recent loss of our assistant director, my schedule simply did not permit this. Indulge me, then, for a moment while I paint a background picture of Chesapeake Bay for those of you who are not familiar with this mighty resource:

- The bay is a special place. It is considered to be the largest and most productive estuary of the 850 estuaries in the United States. Its ecological and economical worth is surpassed by none.
- The Bay basin is 195 miles long, stretching from the entrance of the Susquehanna River in Havre de Grace, MD, to Norfolk, VA. Its watershed spans some 64,000 square miles, including six states and the District of Columbia.
- The Bay's 150 major rivers and streams support some 295 species of finfish, 45 species of shellfish, and 2,700 species of plants.
- The Chesapeake is home to 29 species of waterfowl and is a major resting ground along the Atlantic migratory bird flyway. Every year, 1 million waterfowl winter in the Bay's basins.

And so you may find yourself wondering, "With bounties like these, why have I heard so much about its decline and about efforts underway to restore it?"

At this point, if I had slides, they would quickly switch from pictures of nesting birds, fish harvests, and wetlands to images depicting people—and, of course, their impacts.

The Bay has 5,600 miles of shoreline (more than the entire west coast) and a surface area of over 2,300 miles, a figure that doubles with the inclusion of its tributaries. The opportunities for living and working adjacent to the Bay or its rivers are phenomenal. Factories, urban and suburban communities, transportation corridors, and agricultural operations all hug the shoreline.

With this proximity come the Bay's problems. Declines in the Bay's health became apparent in the mid-1900s. The changes have been dramatic. For example, in 1890, billions of oysters filtered the Maryland portion of the Bay in only 4 days. Currently, the population is so small that about 480 or more days are required. Causes of their decline are many, but are certainly attributed to a decline in water quality, loss of habitat, and disease. These are all issues that have been the focus of our restoration efforts.

In my mind, the Bay restoration effort can be boiled down to its eight basic strengths. By examining these strengths, you can learn many of its greatest lessons—lessons that concern its players, its processes, its structure, and to some degree its politics. Let's give it a try.

First and foremost, I would identify the Bay Program's greatest strength to be its leadership and the goals that they have set. The Bay's leadership occupies the highest levels of government. This leadership—which includes the Chairman of the Chesapeake Bay Commission (representing the legislative branch); the Governors of Maryland, Virginia, and Pennsylvania; the Mayor of the District of Columbia; and the Administrator of EPA (on behalf of all federal agencies)—adopted a set of strong, specific, and comprehensive goals that are unmatched nationwide. These goals cover a comprehensive array of issues including water quality, living resources, growth management, access, public information and education, research, and monitoring. They include such specific goals as achieving a 40 percent reduction in nitrogen and phosphorus by the year 2000 and eliminating fish blockages throughout Chesapeake Bay.

In sum, *the first rule of success is to establish clear, strong, specific, and comprehensive goals and to have those goals embraced by the highest levels of leadership in your region.*

The second rule of success lies in the diversity of the participants. Cleaning up Chesapeake Bay has involved countless players representing all levels of government, the private sector, scientists, and citizens. Beyond the three governors, the 40 Congressmen, and the 10 federal agencies that are involved, more than 700 citizen groups are involved in its restoration. Together, these players bring immense political leadership and financial support to the program. The formal, U.S. Environmental Protection Agency (EPA)-coordinated Chesapeake Bay Program has established 50 and 60 subcommittees and workgroups to ensure that all of these interests are represented and the goals of the program are ultimately achieved.

The third rule of success is that you have to have money. The active involvement of EPA and other federal agencies has leveraged hundreds of millions of state and local dollars. The Chesapeake Bay Program was started by Congress and EPA in the late 1970s and early 1980s. That attention culminated in the signing of the 1983 Chesapeake Bay Agreement, the establishment of the EPA liaison office and a federal commitment of nearly $10 million to the states. Federal assistance to the Bay region has substantially grown since that time; it now amounts to more than $20 million annually. This money, however, is dwarfed when compared to the hundreds of millions of dollars that have been expended by the combined efforts of the Bay states. Still, when you consider that the economic value of the Bay to the States of Maryland and Virginia combined is $678 billion, it's a small price to pay.

Fourth, I must mention the strength of the community as a whole—The Bay's lay people. The citizenry of the Bay region is remarkably knowledgeable. Survey after survey reveals their overwhelming support for the restoration efforts, with many indicating a willingness to make additional financial sacrifices toward the cleanup. For example, Maryland initiated a Chesapeake Bay license plate as a way to raise Bay funds. Originally, a goal was set to sell 100,000 plates in a 2-year period. In the same period of time, 430,000 were sold, with 100,000 selling in the first 3 months.

Fifth, and mandatory to any honest environmental clean-up effort, is a willingness of the players to constantly reassess. In the Bay region, we use our living resources as our bottom line. They are our canary in the mine shaft. If they are not doing well, then we are not doing well. Frequently, new information leads to improved ways of controlling pollution, managing fisheries, or restoring habitat. Regardless of the commitments that we have made in the past, the leadership in the Bay community has demonstrated an ability to regroup, to realign, and to pick up the pieces when a mistake has been made and move forward in a new, and more accurate, direction. I cannot emphasize enough how difficult this is to do politically.

Sixth, the direction of the Bay Program is guided by state-of-the-art scientific research. In this way, our regulations and policies are based on defensible science, something that is difficult with which to argue.

Seventh, the Bay Program's approach demonstrates balance. In a program that spans the gamut from land use policy to fisheries management to recreational boating and air toxics, a diversity of implementation tools is critical. In the Bay region, we have clearly learned that no one approach works best. We have three states, more than 3,000 local governments, and northern and southern orientations. As a result, our tools range from legislative mandates to voluntary efforts. Strong laws

and regulations ensure effective pollution control and resource stewardship in the region, while broad public education and technical assistance programs provide incentives.

Finally, let me say that the success of any program rests in its abilities to demonstrate results. The Bay Program was officially launched in 1983. Since that time, its efforts have held the line on nitrogen and have achieved a 19 percent reduction in phosphorus in the Bay. Successful phosphorus reductions are due to a region-wide ban on phosphate detergents, improved municipal treatment, and soil erosion controls. Nitrogen fertilizer use is down by 30 percent, and seven cities in the region now remove nitrogen from their sewage discharge. Compliance with point source pollution limits is well above the national average, making the Bay Program a model for compliance.

Sure, the Bay has its problems. The 14 million people who live in its watershed will see to that. And our "to do list" is far longer than our "accomplishments list." But certainly our efforts constitute a substantial beginning. The Chesapeake Bay was the first in the Nation to be targeted for restoration as a single ecosystem. Its problems are not unlike those of your area. Unfortunately, its problems are symptomatic of those of our globe. We can learn from the Chesapeake experience.

I hope this presentation has helped you to do just that. Thank you.

Stillwater/Truckee and Carson Rivers

Frank Dimick, Liaison Officer
Mid-Pacific Region, U.S. Bureau of Reclamation, Sacramento, CA

Mark Twain, who got his start in writing in Virginia City, Nevada, during the gold mining era, said, "Whiskey is for drinking and water is for fighting." I guess that kind of set the stage for Nevada.

Today, I'm going to talk about the Carson and Truckee Rivers—two rivers that are completely within one closed basin in Nevada. They are very small systems (the two drainage areas encompass only 3,500 square miles), and yet they have all the same characteristics and almost all of the same problems that a big system, such as the Chesapeake Bay, has. The main problem, though, is water quantity. (This is due in part to the fact that Nevada is the most arid state in the Nation, receiving less than 8 inches of precipitation a year. Many agricultural areas receive only about 5 inches per year.) But the problems we face in the Carson and Truckee watersheds also reflect the wild West history of Nevada.

In the Great Basin in northern Nevada is Lake Tahoe, which straddles the California and Nevada state line and also sits on top of the Sierra Nevada Mountains. Flowing out of Lake Tahoe is the Truckee River; it flows north and then it turns east, through the City of Reno. Then it turns north again and ends up in Pyramid Lake, within the Pyramid Lake Indian Reservation. Pyramid Lake is the terminal lake, or evaporation pond if you would, for the Truckee River. South and west of Lake Tahoe is the beginning of the Carson River. It generally flows northeast and ends up in the Carson Sink area, which is the Stillwater Wildlife Refuge area and again serves as a terminal or an evaporation pond area. Further south is the Walker River, which we will not talk about today because it hasn't had quite the problems. But it again begins in the Sierra Nevada Mountains, flows easterly, and then turns south and goes into Walker Lake, which again is an evaporation area.

These are three of the four major rivers in northern Nevada. There is only one other river, and it happens to flow from the eastern boundary of Nevada into the western part, and also evaporates. So we have these very short rivers—each about 100 miles long—yet, they have every conceivable problem that has ever come to a human's mind.

Essentially all of the water that enters the Carson and Truckee Rivers comes from the snowpacked mountains of California. The Truckee River produces about 600,000 acre-feet of water per year, and the Carson River produces about 300,000 acre-feet of water per year. That's not a lot of water for that area, but it used to be sufficient to meet our needs.

In the mid 1800s, the lure of mining brought people to Nevada. Back then, Virginia City was a thriving metropolis of 35,000 people. The settlers built a large wood-stave pipeline—a large siphon—to carry the water from the Sierra Mountains through the Washoe Valley and back up again to Virginia City.

Later, to support the mining industry, small farming communities were established along the valleys of the Truckee and Carson Rivers. These were used to provide local areas with goods because any shipment, either across the Sierra Nevada Mountains or from the east through Utah, was very difficult.

By the late 1890s to the 1900s, all of the water in the system was used by the late fall each year. Back then as now, an average of 60 percent of the water in the system flowed in April, May, and June, while only 10 percent flowed during July, August, and September, the prime growing season (see Figure 1).

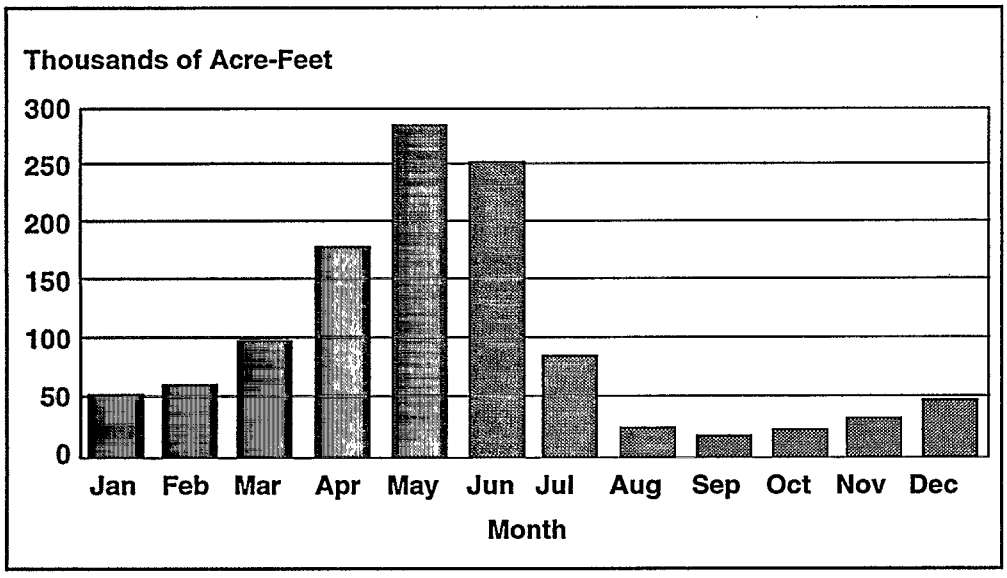

Figure 1. Average flows for major rivers—northern Nevada.

As a result, areas of Nevada that normally had water have begun to dry up. Pyramid Lake is now reduced in size and has a large mud area around it. This lake is home for both an endangered and a threatened species of fish. They are river spawners and must get out of the lake and into the river in order to reproduce. As the lake's water level has lowered, fewer and fewer fish have been able to get into the stream to spawn; consequently, the species are in very serious decline.

In addition, some of the wetlands that were located in the Carson Sink area, in the Stillwater Wildlife Management Area, lost much of their water and became mud areas. Eventually, they completely dried up.

So, as you can see, we have a lot of problems.

To help, the federal government built large irrigation projects, and the private sector followed suit, building their own large irrigation projects. For example, the Newland's Project diverts water from both the Carson and Truckee Rivers through a system of canals and irrigates about 60,000 acres of land near the terminus of the Carson River, near the Carson Sink. The primary crop of that area is alfalfa. Again, this area receives on average just 5 inches of precipitation per year.

Over time, cities in the area grew, bringing new demands for water. The city of Reno, for example, is located in the beautiful valley along the river. City dwellers want to take advantage of recreational opportunities along the Carson and Truckee Rivers. Rafters want water released from the dams in order to have a nice leisurely float down the river. And those who own summer homes and condominiums also demand a share of the lakes and rivers.

Figure 2 gives you an idea how the water use along the Carson and Truckee Rivers has changed. The shaded bar is population growth from 1940 to 1990. The solid black bar is agriculture, and you can see that agricultural use is declining as population centers are taking over the agricultural land. The white bar is urban water growth. We are experiencing a transfer in the water-marketing system—transferring agricultural water to municipal water.

One of the original solutions was to file lawsuits. They started around 1900 and haven't work too well—they've been in the courts ever since. Paying lawyers by the hour, you can imagine what has happened since we started in 1900. Several cases focused on the adjudication of water rights. For example, the adjudication suit on the Truckee River was filed in 1914. It was finally settled in 1944, 30 years later. If that wasn't bad enough, the adjudication suit on the Carson River was filed in 1925 and finally settled in 1980, 55 years later. That cost a lot of money.

The government tried building more dams, which helped solve some of the problems for a while. We looked at ground water as a possible solution. The State of California has no ground water laws, while the State of Nevada has very strict ground water laws. So we have a problem between the two states in areas that have a common ground water basin when it comes to determining how much ground water can be pumped.

In 1967, the government started to issue what they called Operating Criteria and Procedures (OCAP) for their major irrigation project, the Newland's Project. These criteria and procedures limited water

diversion from the Truckee River to try to provide additional water for the endangered species of fish. They continued to issue those interim OCAP until 1988, when they issued a final OCAP, which requires the district to increase the efficiency of its delivery system and thereby reduce water use by about 20 percent, to provide water for the fish. This relieved some of the pressures on the endangered species, but it really only solves one piece of the water quantity problem.

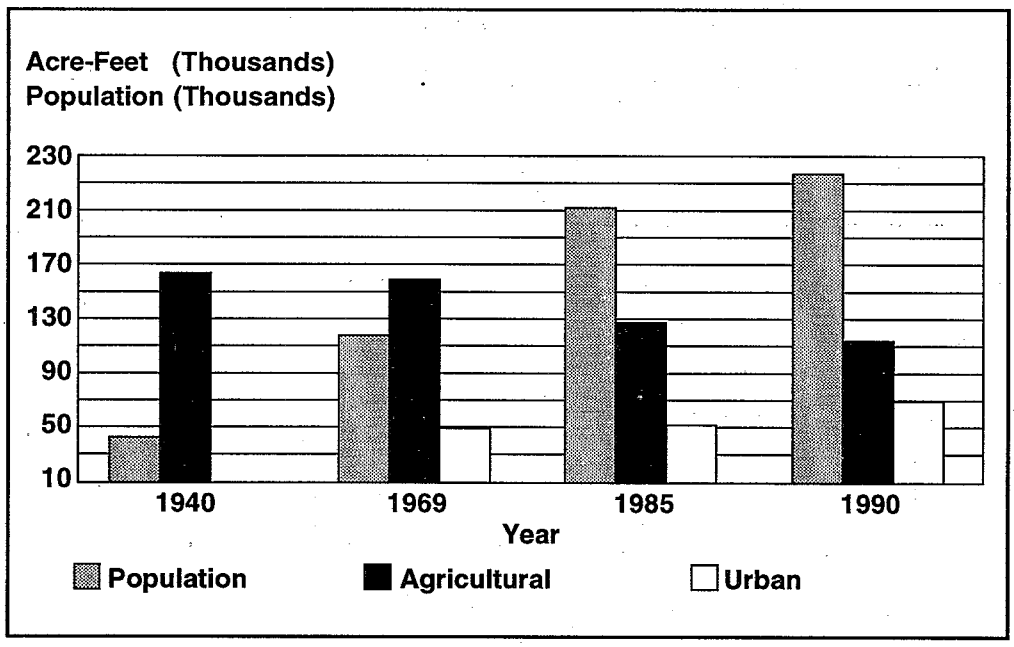

Figure 2. Water use in Nevada—Truckee River.

In 1987, U.S. Senator Harry Reid decided to tackle water issues in a comprehensive manner. He tried to get everybody to the table. In 1990, his efforts resulted in the passage of Public Law (P.L.) 101-618, which sets up the framework for resolving the problems along the Truckee and Carson Rivers. The act provides for the following:

First, it allocates the water between California and Nevada. Although the rivers start in California, California receives about 10 percent of the water and Nevada receives about 90 percent. I don't know why that happened, but I'm glad because I live in Nevada.

Second, the law established the requirement for an operating agreement for the Truckee river. The operating agreement calls for all entities that take water from the river to negotiate how they will operate within the confines of existing law and judicial decisions.

It also provides for multiple use of the water, including a municipal and industrial supply for the cities of Reno and Sparks, at least for the next 20 or 30 years, and water for the assistance of fish, including the dedication of a 226,000-acre-foot reservoir for the sole purpose of promoting the fishery in Pyramid Lake. The latter will provide enough water to support sufficient flows in the river for fish to spawn during years that nature may not provide enough.

In addition, it provides settlement of many of the litigation efforts that were ongoing. Finally, it provides help for the wetlands by permitting the purchase of water on the market for Lahontan Valley wetlands.

Other potential solutions to the water supply problem are being examined by all parties involved. Under consideration is the potential for wastewater re-use and increased irrigation efficiency.

Although water supply is the primary problem in the Carson and Truckee watersheds, water quality is also an important issue. The mining industry, for example, polluted the Carson River to the point that nearly the entire river is a Superfund site for mercury, which was used to extract gold. If you eat fish that you catch in the Lahontan Reservoir, you can only eat one per month; if you're pregnant, you can't eat any.

As a result of P.L. 101-618, we have been able to form a coalition of all the people who have an interest in the issues. Just to give you an idea, representatives from the U.S. Department of Justice, U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, Bureau of Indian Affairs, U.S. Environmental Protection Agency, Pyramid Lake Tribe, Fallon Tribe, State of California, State of Nevada, Sierra Pacific Power Company (a local water and power purveyor), counties, cities, water use groups, and groups such as The Nature Conservancy, Wetlands Coalition, Environmental Defense Fund, and others, are now sitting around the table developing

the actions that will be required to resolve these issues.

As I said before, P.L. 101-618 set forth the framework by which we can do this. The Bureau of Reclamation has taken one of the major roles in accomplishing this, but it is a very difficult situation. Trying to negotiate an agreement when you have about 100 people sitting around the table is hard, and everybody will admit that. But it is a doable thing. We are working within the framework, and we are meeting our objectives bit by bit.

I appreciate the opportunity to talk to you today. I recognize that the basins I have discussed are very small, but that doesn't make the problems on them any smaller than they are anywhere else. It does give us a great opportunity to study within a closed basin all the problems that exist within open basins. Thank you very much.

The St. Louis River: A Grass-Roots Approach to Protection

Michael J. Hambrock, Deputy Director
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Patty Murto, Vice Chair
St. Louis River Board and Carlton County Commissioner
Duluth, MN

In the remote peat and spruce bogs of northern Minnesota, over 175 miles from its marriage with Lake Superior, Seven Beaver Lake sits majestic, the source of the St. Louis River. Flowing as a small wandering stream, the pristine river flows through the Superior National Forest. As it emerges from that sanctuary, the St. Louis River is still profoundly natural. But now it becomes more vulnerable to the uses and potential abuses of people. Mining companies on the Mesabi Iron Range divert water to manufacture taconite pellets. Further downstream, an occasional farm lends a bucolic perspective to the forested river corridor.

About 70 miles downstream, the Whiteface River, having traveled about 80 miles through mainly wild lands, joins the St. Louis, increasing its flow by one-third. Another 25 miles downstream, the river's flow is again increased by a third, as the pristine Cloquet River tumbles into the St. Louis over a long stretch of whitewater. Just downstream, at the City of Cloquet, the St. Louis flows past mills of the forest products and paper industries. Flowing over a series of hydroelectric dams, the river works to produce electricity for the nearby cities of Cloquet and Duluth. Traveling with reduced flows, due to a hydroelectric diversion, the river traverses the spectacular gorges of Jay Cooke State Park and plunges over the Fond du Lac Dam to the still water of St. Louis Bay and the mightiest and cleanest of the Great Lakes, Superior.

The rivers are elegant and largely unspoiled but ripe for economic exploitation, especially from housing developments. Development pressure is intense but so is local grass-roots concern about the future of these rivers—so much so, in fact, that a major local initiative has been underway for several years to ensure that these rivers are protected and preserved for future generations. This paper endeavors to tell the story of this grass-roots movement.

The Rivers

The St. Louis River watershed is drained by three major rivers: the St. Louis River and its two major tributaries, the Whiteface River and Cloquet River. The watershed is one of the largest in the state, draining about 3,600 square miles, most of which are in St. Louis County. The river system also drains part of Lake County (Cloquet River), Carlton County, and Aitkin and Itasca Counties. From its source at Seven Beaver Lake near Hoyt Lakes in St. Louis County, the St. Louis River flows over 175 miles and drops 1,100 feet to its mouth in Lake Superior. The Cloquet River is 99 miles long, originates at Cloquet Lake in Lake County, and drains about 750 square miles. The Whiteface River originates at the outlet of the Whiteface Reservoir and flows southwesterly about 80 miles and drops about 430 feet to its confluence with the St. Louis River near Floodwood.

Timber wolves, bobcats, lynx, beaver, otter, bald eagles, and osprey are occasionally sighted along the St. Louis. Big game sighted include moose, black bear, and white-tailed deer. Walleye, northern pike, and bass are the principal game fish.

Channel catfish are also a popular catch in the Floodwood to Brookston reach.

The Cloquet River is one of the most primitive rivers in Minnesota even though several large storage reservoirs are located on it. These reservoirs regulate stream flow for the operation of hydroelectric generating plants downstream. From its source at Cloquet Lake in Lake County, the Cloquet flows southwesterly to join the St. Louis River after a 99-mile course, dropping about 300 feet. The upper Cloquet River lies almost entirely within the Superior National Forest.

The Whiteface is a fairly large river below Whiteface Reservoir with an average discharge of over 300 cubic feet per second. The river flows through a largely undeveloped and wild area in the Cloquet Valley State Forest.

The river is subject to severe water level fluctuations due to the operation of the Whiteface Reservoir outlet structure which is heavily forested. Fish and wildlife species are identical to those of the Cloquet River; moose, black bear, otter, white-tailed deer, bald eagles, and osprey inhabit the river corridor. Development is limited to the Indian Lake-Island Lake area, but significant development potential exists, especially in the lower reach between Island Lake and the St. Louis River.

Why We Need a Local, Grass-Roots Plan

In recent years, all three rivers, but especially the lower reaches of the Cloquet and St. Louis Rivers, have been subjected to increasing development pressures. Minnesota Power, a large electric utility serving northeastern Minnesota, owns large tracts of undeveloped, unspoiled land that has, up to now, been managed for multiple-use purposes, including hunting, fishing, canoeing, and forestry. Within the last several years, Minnesota Power has begun to sell small, isolated parcels, primarily to adjacent property owners. During 1989-1990, however, a tract of land south of Brookston (220 acres) was sold to Taylor Investment, Inc. Taylor Investment also holds options on larger tracts of Minnesota Power land (1,300+ acres). Since the river planning process has begun, Minnesota Power has reacquired the land it sold to Taylor Investment Corporation and has agreed to withhold future land sales pending completion of the plan.

> "The public demanded a balanced plan . . . ."

In 1990, the St. Louis County Planning Commission was asked to review and approve a subdivision proposal on a 24-acre parcel (8 lots) south of Brookston on the Taylor holdings. This particular proposal raised considerable concern throughout the area, and concern was especially strong in the surrounding townships and from the nearby Fond du Lac Reservation. This involved several issues: suitability of the area for development, potential water quality impacts, potential visual impacts, and increased demands on the townships to provide and maintain roads. More significantly, however, concern was expressed about the potential for additional, similar proposals throughout the lower reaches of these rivers.

This particular proposal quickly solidified public interest in the future of these rivers and exemplified the tremendous development pressure that exists. Most lakes in Carlton and southern St. Louis County are already heavily built-up. These unspoiled, beautiful rivers are located in close proximity to the Duluth-Superior urbanized area and are a relatively short (3-hour) drive from the Minneapolis/St. Paul metro area. These rivers, therefore, are choice areas for new permanent and second homes. Because of the large amount of privately held land, the unspoiled nature of these rivers, and the significant development pressures upon them, it was extremely imperative that a river management plan be crafted while there was still an opportunity to protect these rivers.

Concern is broadly based at the local level. A series of public meetings held early in the planning process indicated that the average citizen is very interested in the future of these rivers. Over 200 people attended these meetings and called for a plan that would incorporate a combination of strict development standards and outright public ownership/purchase of scenic easements on various sections of these rivers. The public demanded a balanced plan—one that protects the rivers, present property values, and land uses and allows for reasonable development where the river environment is compatible with such development.

Strong sentiment was also viewed about the need for the plan to be developed locally. The Minnesota Department of

Natural Resources, over 10 years ago, attempted to propose a plan for the Cloquet River. Even though attempts were made to seek public input, the effort failed. It failed because it was viewed as state government interference in local affairs. The highly successful Mississippi Headwaters Board, Big Fork River Board, and North Shore Management Board planning efforts have convinced local government and state agency officials alike that a grass-roots planning initiative can result in a strong and enforceable management plan that provides solid resource protection and is strongly supported by local citizens. Such a plan will truly make a difference in how these rivers look 10, 20, and 50 years from now.

It was decided that a locally based plan would provide protection of these rivers through zoning, public ownership, and scenic easements. Such a plan will provide certainty to property owners, local, state, and federal officials, and developers, alike, concerning the location and nature of future development. Such a plan would:

- Stabilize property values and the tax base.
- Allow for new development within a carefully planned structure.
- Identify critical and sensitive areas worthy of the full protection of public ownership or scenic easements.
- Identify important cultural and archeological sites.
- Identify sensitive/critical fish and wildlife habitat.
- Identify needed recreational areas, sites, and opportunities.
- Ensure land use practices that protect and/or enhance water quality in the river system.

St. Louis River Steering Committee

In response to significant concern about the future of these rivers from the public, township and county officials, and Fond du Lac tribal officials, agreement was reached in September 1990 to form an organizational steering committee. This committee made recommendations to affected local and tribal governments about the formation of a joint powers board to develop a St. Louis River plan (including the Cloquet and Whiteface Rivers).

Joint Powers Board

The St. Louis River Board was formally established as a Joint Powers Board in March of 1991. The purpose of the St. Louis River Board as defined in the approved Joint Powers Agreement is to *formulate a comprehensive management plan for the environmental protection and wise use of the St. Louis River watershed, including the St. Louis, Cloquet and Whiteface Rivers, and adjacent lands from their headwaters to the Fond du Lac Dam in Carlton County.* The scope of the plan includes standards and criteria for the following:

- Wise use, protection, and appropriate development of adjacent lands.
- Recreational use of the rivers and adjacent public lands.
- Donation or public purchase of critical lands or interest in land in the public interest.
- The sound management of public lands along these rivers.
- Strong cooperative planning and management agreements with the Fond du Lac Reservation Business Committee for the wise management and protection of lands within its jurisdiction.
- The identification of significant historical and archeological sites along the rivers.

The membership of the Board includes elected officials appointed by each member county and town in accordance with the following distribution: Lake County, one member and one alternate; St. Louis County, three members and three alternates; Carlton County, two members and two alternates; and town, a total of six town representatives and six alternates representing 53 affected townships. Alternate members are also elected officials and serve with voting privileges in the absence of the member. The Fond du Lac Reservation Business Committee (RBC) is included on the Board by formal, written agreement between the Board and the RBC.

"a locally based plan would provide protection of these rivers through zoning, public ownership, and scenic easements."

Public Meetings/Issues Addressed in the Plan

Numerous public meetings were held at the onset of the planning process. The major issues identified at these meetings were:

1. Land use management, development proposals along the river corridor, lot sizes, setbacks, erosion, and agricultural and forest practices.
2. Water quality sedimentation, mercury, and various point source problems.
3. Recreation, canoe areas, campsites, litter at access and campground areas, use of the river for hunting, fishing, and camping, and the need for additional recreational facilities and opportunities.
4. Fish and wildlife habitat protection.
5. Archeological/historical/cultural significance of the river and need to identify critical areas/concerns.

Another issue raised was the important need to coordinate the St. Louis River planning effort with county water planning activities, implementation of the revised Statewide Shoreland Management regulations, and the St. Louis River remedial action plan.

As a result of the scoping process and the public meetings, the following major issues are being addressed in the St. Louis River plan:

1. Land Use Management.
   a. Zoning (lot sizes, structural setbacks, frontage requirements).
   b. Land use practices (principles and policies that govern future land use along the three river corridors).
   c. Sewage Disposal.
2. Forest management practices.
3. Agricultural practices.
4. Recreation.
5. Fish and wildlife.
6. Cultural archeology/history.

Citizens Advisory Committee

The first action of the River Board was to appoint a Citizens Advisory Committee (C.A.C.). The C.A.C. is responsible for assisting the Board in developing the plan. The C.A.C. is now in the process of developing specific policies, guidelines, best management practices, and/or standards for each of the major issues. After each section is completed in draft form, it is sent to the River Board for approval to be included in the public review draft of the plan. The advisory committee receives staff administrative assistance from the Board's hired professional staff from the Arrowhead Regional Development Commission.

The advisory committee is composed of 27 members representing a variety of interests from throughout the watershed. The interest areas represented on the committee are as follows (each interest area has two representatives, except for the "other" category, which includes seven *at large* representatives:

1. Logging industry
2. Environmental
3. Developers
4. Tourism/Industry
5. Industry
6. Agriculture
7. Recreation
8. Sports groups
9. Riverfront property owners
10. Fond du Lac Reservation
11. Other

Staffing

Staff support for this planning project has been purchased by the St. Louis River Board from the Arrowhead Regional Development Commission (ARDC). ARDC provides primary staff support services to the St. Louis River Board for the following:

1. All necessary administrative, professional planning, and facilitation services to the St. Louis River Board and its Citizens Advisory Committee, including:
   a. All intergovernmental coordination activities.
   b. All public and media relations, press releases, press conferences, public meetings, and preparation of public informational materials.
   c. All meeting schedules, mailings, agendas, duplicating, printing, and meeting minutes (except printing of final plan, and maps).
   d. All meeting facilitation for Board, advisory, and public meetings.
   e. Under the direction of the Board, represent the Board before local, state, and federal governmental bodies.

f. Assist the Board with funding proposals and applications, and in pursuing the resources for priority needs as directed by the Board.

2. Serve as fiscal agent for the Board, providing for the fiscal management of Board funds, with all funding decisions to be made by the Board.
3. Assist the Board and its advisory committees in the preparation of the management plan.

Photo courtesy of Michael Hambroch

St. Louis River, Minnesota.

In addition to staff services purchased from the ARDC, the professional resources are being contributed by the local units of government and RBC. This includes planning, zoning, legal, natural resources, forestry, highway, and other relevant local government, and tribal professional staff. State and federal agencies actively involved in development and resource management activities within the St. Louis River watershed also provide technical assistance to the Board. Minnesota Power has also offered technical support and assistance with various aspects of this project.

Results

Funding

The River Board's planning initiative is being funded from a $297,000 grant from the Minnesota State Legislature through the Minnesota Department of Natural Resources. The funds come from the Minnesota Environmental Trust Fund, the source of which is state lottery proceeds. The funding was made possible primarily through the efforts of the geographically broad-based St. Louis River Board and the legislative delegation from northeastern Minnesota. The chief sponsor of the River Board's funding proposal was Representative Willard Munger, the most senior member of the Minnesota Legislature.

The River Board's funding proposal was broadly supported by local units of government and concerned grass-roots citizens throughout the 3,600-square-mile watershed. The support was shown through numerous public meetings and with overwhelming cooperation of local officials, state legislators, and state and federal resource agencies. The River Board also clearly demonstrated that these rivers were worth protecting and that they were threatened from heavy development pressures. The tremendous grass-roots momentum to protect the rivers was the critical factor in obtaining the funding and will be, we believe, the reason this effort will succeed.

Major Milestones

The River Board and its C.A.C. have completed major components of the plan, including identification of major issues to be addressed, goals and objectives, classification system, land use principles and policies, and land acquisition criteria. Yet to be developed are zoning standards, forest management practices and standards, agricultural practices and standards, and implementation strategies.

Results so far indicate that the Board and its Committee are developing a strong protection plan for these rivers. This is evidenced by the Board's goal statement, which reads in part:

> The River Board has a special responsibility to represent the best interests of all the citizens of this state, with regard to planning for and

managing this watershed. The river system's natural beauty, environment, and cleanliness should be protected.

Also, a key land use principle found in the draft plan reads:

> The principles and policies of this plan are intended to guide local, state, and federal actions, plans and ordinances to promote the protection, preservation and proper and orderly management of the St. Louis, Cloquet and Whiteface Rivers and their adjacent shoreland environments.

Land Acquisition Opportunity

As indicated earlier, Minnesota Power had proposed to start selling riverfront parcels to private individuals in 1989. Minnesota Power owns approximately 22,000 acres of prime riverfront property along all three rivers and has made a corporate policy decision to sell. Minnesota Power has been fully cooperating with the Board as it develops its plan and has two representatives on the C.A.C. Minnesota Power has agreed to stop individual land sales of riverfront lands until the planning process is completed. In addition, the St. Louis River Board has initiated a major effort to obtain state funding to acquire environmentally important lands for state ownership (to include but necessarily be limited to, those parcels for sale by Minnesota Power). These lands, if acquired by the state, will afford an unprecedented level of protection for these rivers.

Conclusion

The mission of the St. Louis River Board is to develop a strong, grass-roots-driven plan to protect the St. Louis, Cloquet, and Whiteface Rivers for generations to come. The Board and its C.A.C. are actively engaged in a difficult, yet productive and positive common sense process that will accomplish this mission. The St. Louis River Board organization represents a group of more than 50 hard-working people who have committed thousands of volunteer hours to the protection and preservation of these beautiful rivers. These people are indeed an inspiration to us all and will truly make a difference for our children and their children.

Panel Discussion

Visions for the Future

On Wednesday, March 24, WATERSHED '93 presented a national videoconference. The sessions were broadcast live from the hotel ballroom, and interaction among panel members, the live audience, and downlink sites throughout the Nation was made possible through satellite communication technology.

Greg:

Good morning. I am very pleased to be the host for this nationally broadcast portion of WATERSHED '93. Our sessions today will focus on *Visions for the Future* of watershed management.

I'd like to propose that there are four primary goals that should drive us and empower us as we think about a vision for watersheds.

First (and this reflects my Nature Conservancy biological bias), we must think about maintaining ecological processes of watersheds and we must preserve the biological diversity of aquatic ecosystems. Second, we must ensure an adequate supply of usable water for public consumption. Third, we have an obligation for public health and safety to maintain excellent quality of our ground and surface waters, all of which are influenced by their watersheds. Fourth, we have a very important objective of providing for compatible economic development within watersheds so that people can live and prosper in harmony with nature. We need to come up with plans and programs that provide for the sustainable human use of lands and waters and natural resources within watersheds.

Now, a watershed is a physical reality. You know, we joke that it is really simple to plan because water runs downhill, but watersheds really are the proper geographical context within which we must plan because water does run downhill. The human activities within these geographical areas give us both the charge and the necessity to go ahead with watershed planning.

Watershed planning and management can vary greatly in scale. Some efforts are necessarily vast in scope, concerned with watersheds that encompass several states. Others are concerned with very small watersheds at a local level. So we need to provide for watershed planning at many scales from local to regional.

Watershed management, of necessity, must involve all levels of government—federal, regional, state, tribal and local—as well as private landowners and businesses and all the other stakeholders who care about the quality and quantity of water as well as the biological resources of the watershed. Because comprehensive watershed management requires the active and well-coordinated participation of all levels of government, as well as numerous other parties with a stake in the outcome, our panel today is carefully constructed to provide viewpoints from local, tribal, state, and federal governments. We're going to be re-

L. Gregory (Greg) Low, Vice President for Major Program Development, The Nature Conservancy, Arlington, Virginia, served as master of ceremonies and panel moderator. Panel members included:

- The Honorable Parris N. Glendening, County Executive, Prince George's County; and Chairman, Environmental Policy Committee, Metropolitan Washington Council of Governments, Prince George's County, Maryland (a local perspective)
- Bill (Billy) Frank, Jr., Chair, Northwest Indian Fisheries Commission, Olympia, Washington (a tribal perspective)
- Steve W. Tedder, Chief, Water Quality Section, North Carolina Department of Environment, Health and Natural Resources, Raleigh, North Carolina (a state perspective)
- Martha Prothro, Acting Assistant Administrator for Water, U.S. Environmental Protection Agency, Washington, DC (a federal agency perspective)
- Jimmie Powell, Professional Staff, Senate Committee on Environment and Public Works, Washington, DC (a Capitol Hill perspective)

lying on you, the audience, to provide other points of view.

Before we get started with the speakers, I'd like to welcome our participants from satellite downlink sites across the Nation. People are tuning in from more than 30 downlink sites. These folks are concerned about places such as the Connecticut River watershed (in Vermont, New Hampshire, and Canada), the watersheds contributing to the Gulf of Mexico, the Upper Rio Grande (in Colorado, New Mexico, and Texas), and the upper Columbia River (in Idaho, Montana, Washington, and British Columbia).

> "... we need to have both protection of the water and the watershed and also a viable economy."

The U.S. Geological Survey put together wonderful maps to help us understand more about where our broadcast audience is coming from, in more ways than one. Let me just focus in on one of them, the Puget Sound (see Figure 1). The shaded relief enlargement of the subregion gives you a feel for the lay of the land out there—pretty mountainous. The white line delineates the USGS subregion; each white dot symbolizes 10,000 people, so you can get a feel for the population in the area. Also included is textual information on land use in the subregion.

When folks begin calling in later, we'll put up their subregion information as they speak so that we'll all know a little more about their part of the country.

We are going to try to keep today's panel session as flexible and interactive as possible. I only ask that we keep our discussion within a three-part framework:

- Vision—what we are trying to achieve.
- Barriers to achieving that vision.
- Strategies or actions that we need to take.

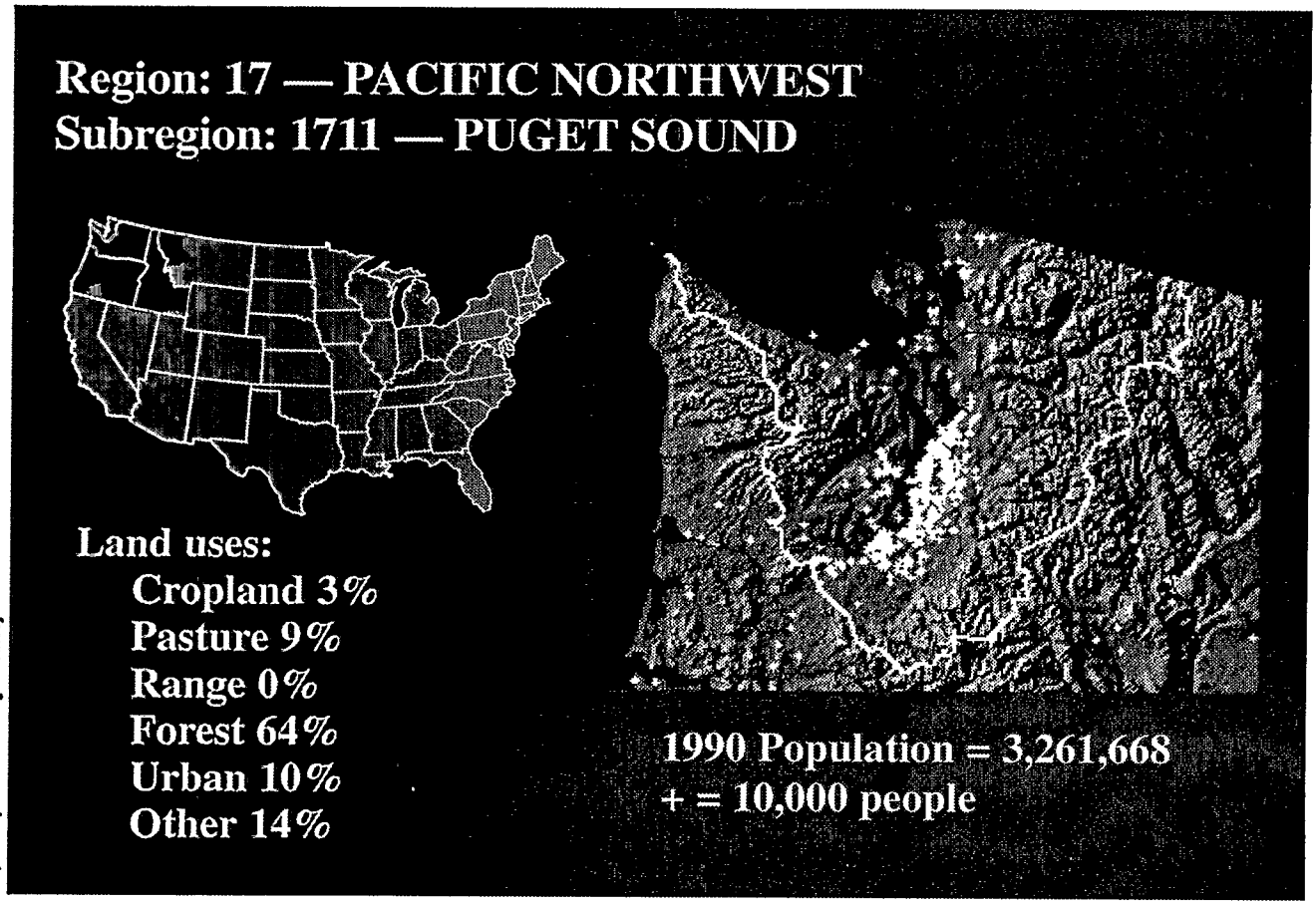

Figure 1. Example of image on screen as callers posed questions.

Now each of the panelists will take a few minutes to tell us about their vision for watershed management.

Parris:

First, let me say that it is the vision of Prince George's County and the State of Maryland that we need to have both protection of the water and the watershed and also a viable economy. It is a false dichotomy, I think, to say that we'll end up with either one or the other. If we do that, invariably the environment loses because people need jobs. We're trying to develop a program that will bring people together to say we're going to be successful with the economy and we're going to be successful in protecting the environment

Second, we must recognize that it will come from the bottom up. It must involve people; it must involve communities. People must have an ownership of the program. We, who manage watershed programs, simply cannot begin to deal successfully if the people who live in the watersheds are not involved themselves. Think of the number of small tributaries that run into the streams, that run into larger rivers, that run into the Chesapeake Bay. To think of a government program that handles all of that is almost staggering, and certainly beyond our cost abilities.

We're trying to take an approach that will involve people—to help them understand their roles and responsibilities and the connections within the system. For example, showing them that storm water drains are part of the whole system for the watershed and that what they put down the drains will affect the health of the waterbody—in our case, the Chesapeake Bay.

Watershed management really needs to be a full governmental approach. All levels of government have key responsibilities. In terms of leadership, the federal government needs to set overall policies. More specific plans should be handled by the state governments. We have quite a few of them, including the Chesapeake Bay Critical Area Commission, which have been working very successfully. But implementation really comes down to the local level. The approach has to be one which is meshed together as a system. It can't be a higher level of government mandating without funding—saying that a local government must do something just because they think that it needs to be done. Instead, we need a cooperative system, where we each have our own niche—system where we mobilize the energies of the community, and where we say we're going to do something well, and have a viable community at the same time. That's the vision I have.

Billy:

What I've done my whole life is live on the watershed—the Nisqually watershed. I continue to drink out of that river today.

All of the other watersheds in the Northwest are not in that same condition. Look over to the Snake River and the Columbia River. There are endangered species there that are now affecting everything that is happening —the economy, the electricity, the agriculture. Also, there is gridlock as the debate over these issues continues. What's happening on that watershed is not a scientific problem—it's a social problem.

> "Let the watershed breathe. . . ."

We have to make some social changes as well as institutional changes in order to address watersheds. We need to teach people coming out of universities how to approach a watershed. You cannot approach an old growth tree by looking at it in board-feet. That's what they've been taught to do because it translates into money. An old growth cedar or fir, which is a few hundred years old, should be looked at as part of the watershed. We need to realize that either the watershed is clean and breathes, and it is healthy, or it is sick.

As people, we have to do something about watershed protection. People move inside a watershed. Eventually, if you do not protect the watershed, you have a watershed similar to the ones we have on the east coast. We in the West should be learning from what happened on the east coast, but we haven't learned a thing. And now it has come to a point where the federal government will make decisions that nobody likes. Then the U.S. Congress will write a law that nobody likes. In the end, there will be no flexibility for people at any level of government to work on ameliorating the problems in the watersheds.

We have to stop the debating and start to find solutions. The timber industry, agriculture people, hydroelectric people are all writing reports that place blame on

others. We have to be able to admit that we made a mistake and start moving on from this day to overcome the mistakes of the past and back off the watershed. Let the watershed breathe and let it start healing. It's going to take 100 years for some of these watersheds to heal. We have to look at the people and address the people problem. And we have to address the economy. But we have to back away and look into the next 100 to 200 years. Otherwise, we're not going to be here.

Steve:

We have implemented watershed planning statewide. This approach to water quality management is not only important, it is essential. Watershed planning has provided us the ability to integrate programs to a level that we've never done before. It allows us to educate the citizens about the issues and needs within basin areas. The walls are starting to break down, and we're starting to work together. It gives us the ability to evaluate the issues for each specific area of the state. This is important because each one will have different problems and, therefore, different solutions.

> "The approach is ecologically sound and scientifically valid. . . . it is also very politically achievable. . . ."

From a state perspective, we realize that we have limited resources, and basin-wide management allows for more effective use of resources. Additionally, it allows for more effective plans being put into place, more public awareness, and more consistency, which is something the public has demanded for years.

It also provides us a mechanism to allocate resources—an equitable and systematic mechanism. It puts us in a mode where we can stress predictability. Therefore, the regulated community knows what to expect from public agencies.

The approach is ecologically sound and scientifically valid, which are two very important aspects. But what we have found is that it is also very politically achievable, whether we're talking about a small area, a state, or a combination of states. For the first time, we're starting to see a reduction in the fragmentation of programs. State, county, and local governments are all working to break down the fragmentation. But, most importantly, it is publicly supportable.

Martha:

Speaking as someone who has worked in government on the environment for many years, as I know much of the audience has, I think we need to look at our own house to see if it is in order before we can deal effectively with the watershed approach. I want to talk about how we can get our government institutions together to deal with a more holistic approach.

At the U.S. Environmental Protection Agency (EPA), we have a wonderful mandate. The Clean Water Act is perhaps the best of the environmental statutes, which is not to say it's perfect. It gives us a great deal of flexibility, and it does set forth as a holistic goal the protection of the biological, chemical, and physical integrity of our nation's waters.

However, we have focused only on certain aspects of that act over the years. We tried a watershed approach in the 1960s and early '70s. We found ourselves tied up in a lot of debate and disagreement. We didn't have the science or technology to allow us to be holistic, so we broke the issues apart and became specialists to solve the most obvious problems. We became specialists in chemistry, industrial technology, funding, enforcement, permits, and law. We all became such specialists that we quit talking to each other. We separately learned more and more about less and less, and we missed the point.

I liked Billy's description of watersheds as living, breathing organisms. We government implementers might be compared to medical specialists looking at only one part of the patient. We need to sit down with that patient and deal with the patient as a whole human being, with respiratory problems, circulatory problems, muscular-skeletal problems, or whatever problems there may be. We also have to deal with the spiritual side of things. Our watersheds are not going to be protected in the long run unless society learns to treat them with dignity, love, and respect. That's part of the healing process we have to go through.

We see ourselves at EPA as providing leadership and advocacy for some watersheds, especially where there is an interstate interest or a national concern. But we can't be the only leaders. Not only do we recognize this fact, but we don't want to be the only leaders. Leaders have to be identified in each of our watershed areas. They're going to come from all levels of government and from many different agencies, as well as

from tribes and the private sector. Partnerships are great, but we can't just become people who talk to one another. We have to move forward and take action.

Jimmie:

Last October was the 20th anniversary of the Clean Water Act. In the first 20 years, we made a lot of progress controlling point source pollution— sewage treatment plants and industrial facilities that discharged into the waters. That was possible with national legislation and national regulation. You can identify technologies and give instructions nationally.

The challenge for the next 20 years is principally nonpoint source pollution—the runoff from farms and city streets. I think Congress will be interested in watershed planning for three reasons. First, the strategies to control nonpoint pollution must be designed locally. It's hard to direct progress from the federal level, so a local element to the Clean Water Act is necessary to make progress.

The second reason involves resources and energy. The amount of dollars available at all levels of government is short these days. In 1987, when Congress last addressed the Clean Water Act, it created a program called the National Estuary Program. Seventeen communities across the country have written or are writing comprehensive plans for their estuaries, which is exactly the kind of watershed planning we're talking about today. Without expecting it, Congress released a lot of energy in those communities. People love their streams, lakes, and bays. They don't necessarily love permits, regulations, or even the Clean Water Act. If we can tap the energy they have for their own water resources, we have a chance to make progress in the next 20 years.

The third reason is ultimately practical. The Clean Water Act now focuses on sources of pollution, principally chemical agents that cause that pollution. However, it doesn't focus on the natural resource—the water within its watershed. We've come to a point where we need to address the biggest risks. We can't continue to spread our resources evenly across the country and expect progress. The only way to find the biggest risks is to go to the local level and find out why a watershed has problems and what must be done in order to restore its bounty.

Congress is likely to be interested in revising the Clean Water Act for three reasons: to control nonpoint pollution, to release the energy of the people at the local level, and to reorganize the Clean Water Act so that the precious resources that we have are focused on the greatest risks.

Greg:

I hear a fair amount of commonalty regarding your visions for watershed protection and management. The common vision includes environmental conservation and compatible economic development. It includes looking at watershed protection as a social problem. It includes a systematic approach that involves all the different levels of government. It absolutely requires local participation to succeed.

We will take questions from the audience shortly, but first I would like to ask the panelists if any of them would like to talk about the barriers that they run into when trying to use a watershed approach. What are the barriers that keep us from being able to accomplish this intergovernmental cooperation, local involvement, ecological and economical protection while dealing with the social issues at hand? What hurdles do we have to cross?

Parris:

I've spent 10 years now as County Executive and 8 years on the Chesapeake Bay Critical Area Commission, so I have a few points to make on this issue. First, we're talking about human activity, which in many cases is the major point of disruption. So, in an urban setting, we're trying to protect things like habitat, drainage area, tributaries, and at the same time allow for a tremendous amount of human activity. When we put our law (Critical Areas legislation) together, we mandated that in critical areas along the waterways of the Chesapeake Bay watershed, a buffer portion of 100 feet from mean high tide could not be disturbed. You would have thought that we declared the entire east coast to be off limits! And yet we were just trying to move human activity back a relatively small amount. People say the water is there for the purpose of human activity and all is well. So that is a real challenge facing us.

I also think that when a problem appears to be complex, we want to study it, then study it again, then form a task force. Meanwhile, the deterioration continues to occur.

Finally, given the fiscal pressures right now, the federal government seems to prefer to solve a problem by mandating that a lower level of government solve it. Then the next lower level of government, the state governments, say they will solve the problem by mandating that a lower level does it. So instead of recognizing that local governments also have limited resources, the government's higher levels keep on passing us the work. To be successful in meeting environmental mandates, local governments need more freedom, not just nationally uniform methods determined by the federal level. For example, we're finding that in the Chesapeake Bay air pollution is a major source of water pollution. So we're looking at the Clean Air Act to help us resolve this problem. I believe the policy behind the Clean Air Act is absolutely correct, but we are required to take certain actions by 1997, even though there isn't any money to help us. So those are some of the barriers we see every day at the local level.

Questions from audience, including call-in questions:

Q: Regarding visions and barriers, the City of Annapolis has a watershed management program, but our scale is very small—we are local. We have capital project funding to improve our watersheds. Because we're 87 percent developed, it's pretty much the drainage ways that are going to be stabilized. We have state and EPA grant money. We have everything lined up to go to meet this vision of watershed protection. One of the barriers we have is the Clean Water Act section 404 program managed by the Corps of Engineers—We can't get our permits from them. I'm not criticizing them; instead, I'm saying that they might be so institutionally overburdened with this program that they can't get things out. They are paper-heavy.

Martha:

I think there are some improvements that we can see in the 404 process, and I don't want to blame the Corps of Engineers because the process is rather complex. Currently, about 95 percent of all permits are approved and the vast majority are approved within 6 months. Nevertheless, there are some improvements that can be made that we are working on right now. I think one of the keys is to support comprehensive wetlands planning and management, with advance identification of the areas to be protected. We need to get the state and local governments involved with that process up front.

Q: As a representative of local government, my question regards Clean Water Act reauthorization. What would you predict would be the minimum population for municipalities to be under the future storm water management regulations?

Jimmie:

Congress will address storm water when the Clean Water Act is reauthorized. Currently, cities with populations above 100,000 have submitted their permit applications and the states are now reviewing those applications.

In the future, I see the program splitting into two directions for cities with populations under 100,000. In large metropolitan areas where the primary city has already planned and received a permit for its storm water program, I expect that all cities within the metropolitan area will be required to participate in the metropolitan area storm water permit effort. Where cities are isolated (that is, not part of a metropolitan area), I expect that Congress will require a nonpoint source-oriented watershed approach, rather than permits. Under this approach, the storm water controls that apply to a small city would depend upon the whole watershed plan.

Q: Looking at all the federal agencies involved in the water management area—the Geological Survey, EPA, the Department of Agriculture, the Bureau of Reclamation, etc.—shouldn't watershed management reorganization start at the top? In many ways, states appear to more organized for internal cooperation than the federal agencies.

Steve:

There will have to be some changes in structure. When I look at the Clean Water Act, I don't think it's broken. But we have to recognize how it is administered—section by section. A water program in any one state may be dealing with multiple grants with multiple purposes—all water grants—but involving a tremendous amount of bureaucracy and red tape. Dealing with the paperwork takes experts away from solving problems.

I'm sure many people here can identify similar administrative problems. I call it tunnel vision. Our approaches to section 106 of the Clean Water Act and section 319 have become so tunnel-visioned that we have forgotten the rest of the water program. Basin-wide protection pulls all of those programs together. That is the key. Let's throw out the red tape and get down to business solving problems.

Jimmie:

Looking from the top down, it's really difficult to know which part of the local government is going to solve a problem. In the various watersheds, the problems are different. If we're ever going to control nonpoint sources of pollution, these sources are going to have to deal with agencies with which they are familiar and trust—farmers with the SCS, foresters with state forestry agents, developers with city and public works departments, and so on. In organizing a watershed plan, one of the challenges is identifying the various agencies that should be involved and finding the right local agency to organize this activity and to bring it to a conclusion. I think that argues for a bottom-up rather than a top-down approach to watershed planning.

Q: Do you see a role for computer modeling to predict the economic and environmental impacts of policies and actions set for our watersheds?

Parris:

We do and in fact we have used some of these techniques in our work for the Critical Area Commission and other projects. Computer modeling helps us to project the effects of alternative approaches. One of the biggest challenges is the availability of data on a watershed basis. We tend to collect data for different purposes using political jurisdictions, often county or census tract and so on. So there is a lot of opportunity to improve our information base.

I would also recommend that people try not to get too wrapped up in computer modeling. I have seen programs that produce models and studies of those models, and analyze alternative approaches on those models, and nobody ever does anything on the ground. So as a supporting technique, yes there is some promise in computer modeling, but we should make sure that it is not a substitute for real action.

Q: The Confederated Tribes have successfully used their treaty rights in Oregon to find solutions and to leverage federal agency actions to restore fisheries and watersheds. Comparatively, they have done this on a small scale. This primarily results from pressuring federal agencies to fulfill their trust responsibilities. In some federal agencies, this results in enhanced congressional and public support. Will other federal agencies, such as EPA, the Army Corps of Engineers, and the Forest Service, take advantage of treaty rights to use their responsibilities to implement changes in watershed restoration and protection?

"one of the challenges is identifying the various agencies that should be involved. . . ."

Billy:

What we're doing for our watershed is similar to what the Confederated Tribes are doing. We see our water disappearing, we see our animals disappearing, we see our medicines gone. We see all the problems that people are talking about here—people problems.

We have treaties that we signed around 1855. But, when you go to the agencies, they don't take advantage of the treaties to take action. The State of Washington is just now taking advantage of the agreements found within treaties that were signed and incorporated in the law of the land. I think that through education we can make it happen more often.

You have heard this today in this room—the problem is that the people do not have any faith in their government anymore. The government doesn't have a constituency out there. The State of Washington has $17 billion in their annual budget and only 3 percent goes toward natural resources—3 percent! There aren't going to be any natural resources left if they don't start putting money into solving problems. Natural resources can work with the economy if we make it happen.

We have to take the children of our land—and all of you in this room are children of the land—and start educating them on environmental issues. We have to start with the children.

We have to change laws. We are in gridlock right now. We have to move out of

that gridlock and start moving forward with a comprehensive plan. We need leaders to start providing leadership. Politicians need to start leading this group of people toward education and a comprehensive watershed plan. And we need federal agencies, states, counties, cities, and people to be involved in coalitions to take us forward. Otherwise, we're not going to get anywhere.

Q: Watershed councils are necessary in order to work holistically with all the stakeholders. We need funding for these watershed councils. What is EPA going to do with their grant programs to give such councils long-term abilities to enact their major policies and priorities? Right now federal agencies are designed around specific programs and funding is not targeted for watershed programs. Do we have to overhaul the entire budget process? What should we do?

Martha:

Realistically, EPA is not going to be the source of funding for all watershed projects across the country. And we can't expect funding increases to be dramatic over the next few years with the fiscal problems the federal government is facing. There will need to be many parties coming to the table to help fund these efforts.

> "We need to look into leveraging and combining resources. . . ."

We are, however, increasing our help for watershed protection. President Clinton has asked for significant increases in our nonpoint source program in his economic stimulus plan. He has requested that $47 million in additional funding for this fiscal year go toward what we call "green" or "natural" infrastructure to help promote watershed integrity and to create jobs.

In the out years, the President's plan would double the funding for nonpoint source program. This funding would go to the states and could be used to support watershed programs. We're also encouraging the states to increase use of other existing funds for watershed planning, which many are doing.

We need to look into leveraging and combining resources—pooling our efforts and using what we already have more effectively. To do this we need to educate ourselves, to turn away from our specialties long enough to look at the entire picture, and to work together more in partnerships. I think that we all have been guilty of being too "turfy," including EPA. It's going to require a new attitude, which I think could be even more important than new legislation.

Parris:

I think one of the real challenges is to get all of the entities to work in a far more flexible approach. Part of the problem stems from Congress, where they have a tendency to micromanage. They give a specific amount of money to a specific program on a state-by-state basis when the river basins not only face different problems from one another, but are also multi-state.

I look at the success of the Potomac River Basin. Everyone had a common direction there; it was almost a national mission adopted in the sixties. Now it's almost impossible to have that same sort of flexibility.

In Prince George's County, we imposed a dedicated storm water management property tax specifically to meet some of the challenges we were facing. It was a flexible funding approach. To the best of my knowledge, we were one of the few local jurisdictions to do that. But when we try to match that with other money sources, we find that they are very narrowly restricted. And we run into serious problems when we try to say that we are going to direct these funds to clean up a little river, such as the Anacostia.

I would rather see us create more flexibility in the application of these funds than have the tight management coming from above—the purpose of which might be well-intended, but the practical application is very difficult.

Q: My question is about the Chesapeake Bay and the 100-foot buffer requirement. We live in a coastal plain region and, consequently, our storm water does not sheet-flow through the buffer. Rather, it is discharged by a ditch or a storm drain. I can understand a buffer in the northern part of the Bay watershed where there are steep slopes and various soil types. But at the coastal plain regions, perhaps a relaxing of the 100-foot buffer and additional performance standards at the outfall systems would be more prudent.

Parris:

I understand the issue and the different topographies. But in all candor,

even on the coastal areas, we find that 100 feet of either tree or grass buffer does a lot of filtering. To have trees and even grasslands as a filter for the runoff going into the waterways, according to every indicator, has worked. I find it difficult to believe that a 100-foot buffer creates an insurmountable problem.

I recognize that buffers do not alter runoff water that flows through ditches and storm drains in the coastal plain. However, not all the water flowing from the land is routed through drains and ditches and, consequently, I believe that it is appropriate to apply buffers in all areas of the watershed, both upstream and downstream. In other words, we should have both storm drains and ditches *and* buffer strips in the coastal plain, not just one or the other.

Greg:

Parris, as I understand the Maryland law, the 100-foot buffer applies to the urban areas, but not agricultural areas. Yet, we know that agricultural pollution is one of the major problems in our watersheds. Can you clarify the buffer requirements for me?

Parris:

Even in the agricultural areas, we have a buffer requirement. In some cases the agricultural buffer is only 25 feet, but there is still a buffer requirement there. We're trying to literally back up agriculture from the water's edge. In the eastern shore of Maryland where the land is very flat, it is fairly common to farm right up to the water's edge. We're trying to reestablish a small buffer, even a 25-foot buffer with natural grasses to serve as a filter.

Our agricultural community is very cooperative in this effort, and we're trying to combine buffers with some best management practices to keep fertilizers and pesticides away from the water.

Q: *In many areas an important component of watershed management is the use of best management practices (BMPs). Many localities are hoping to use regional BMPs instead of on-site BMPs, especially when they're looking at it from a programmatic point of view versus a site-by-site point of view. Is there acknowledgment on the part of EPA that many localities wish to use regional BMPs? How does EPA anticipate responding to this issue?*

Martha:

First of all, I'm not aware of any group that has been formally established to look at this issue. We have recently issued guidance on BMPs under the Coastal Zone Management Act. I'm only speculating, but perhaps there is a question as to whether regional BMPs would satisfy the requirements of the Act. It would be a legal question.

Our philosophy generally is that you need to do what *you* need to do for water quality on a site-specific basis. You need to design your BMPs according to the problems that you are facing in your particular watershed. In some cases the regional approach is desirable, but in other cases you have to deal with specific sites that need to be controlled.

Q: *Billy mentioned the need to address the people problem and to redirect training to be more sensitive to other values, but that's more of a long-term approach. How do we do something in the short term to give people ownership, and do you have any examples that you've dealt with in breaking this gridlock?*

Billy:

In some of the models in the Northwest, we started the watershed approach by bringing in all of the people in the watershed: industry, hydroelectricity providers, tribes, farmers, private landowners. It took us about 4 or 5 years just to get these people together to talk about watersheds.

There were sensitive areas of concern for many people. We had lawsuits. For example, my tribe sued the utilities for the lack of water flow on the river for our salmon. But during that time, we were slowly bringing people together—educating them on the watershed.

You have to be very committed to putting a watershed council together. You have to have patience. You have to change your attitudes—you have to look at government and agencies as tools. You also have to look at your neighbors as positive tools. You have to involve the leadership of the area, whoever they are—farmers, Republicans, or Democrats.

You have to bring these people into the fold and make them feel good about taking part in the watershed. They have to feel proud of taking part in protection of the living, breathing watershed. You have to address all the interests and somehow

balance how you're going to bring it back to life if it's unhealthy. If it's healthy, you need to address ways to keep it healthy.

It's a long, hard job and it's going to take 100 years to do it. So put into your mind that it's going to take 100 years. But who's going to do it? Nobody's going to do it unless we do it. We're the only ones who can do it. The courts can't do it. The legislation can't do it. The U.S. Congress and all the money in this country can't do it. We have to do it. We need to get more miles for our dollars and we need to be positive. There are models all over our country—we've heard them right here. People are coming here with concerns that we have to protect our watersheds.

Q: Soon, P.L. 566, a watershed protection and flood protection act, will be 40 years old. It has had great success in providing flood control, water supply, fish and wildlife quality, recreational quality, and land treatment in watersheds. Why not expand the authority and funding of this program, which has had a good track record, instead of starting up new federal watershed programs under the Clean Water Act?

Steve:

In regards to P.L. 566, you can use it or the 1985 and 1990 Farm Bills, or any of the other provisions that some of the nonpoint source agencies have been working with for many years, with a good deal of success. I think part of the problem is that these successes have been the best-kept secrets known to man. Nobody knows where the successes are. The overlays that we talk about in our own governmental programs—the bureaucracy, the refusal to work together—are worse in some of the agricultural agencies than in state government as a whole.

So we're not necessarily trying to create something new in the Clean Water Act, but to set a framework for coordinating existing programs. I'd like to see some of the agricultural agencies come together and share information on those successful projects. I think we will be pleasantly surprised at the progress that we have made with nonpoint source pollution issues and solutions if can ever get our hands on the information.

Q: There are thresholds to growth and development, beyond which ecological processes and diversity decline. Water supply and quality are adversely affected. When do we say that there have to be limits on growth and development in order to sustain the integrity of watershed ecosystems? Also, how will transportation planning play into a vision for the future for our watersheds and the attempt to heal them? More specifically, will walking and riding a bicycle ever be considered a BMP?

Parris:

As a practical matter, we ought not be in a growth versus no growth frame of mind. First of all, unless we're going to come up with all kinds of answers ranging from economic growth to population control, immigration, and a variety of other issues, there's going to be growth.

I think the debate should center around directed growth. Where is the growth going to be and where is it not going to be? We should be concerned with stopping this low-density sprawl that is consuming every acre of open space that we have.

Instead, we should concentrate growth in a way similar to the European model, which makes much better use of land than we do in the United States. We have the attitude here that everyone has the right to build whatever we want on our land because it is our land. As a result, we forget the common interest.

There's another side of that coin that most of us are not willing to admit. If we're going to take a growth management approach, than we must have nodes of higher-density growth. What happens is that everybody says they don't want the low-density sprawl eating up the land, but they also want to own their own 1-acre lots. You can't have 1-acre lots everywhere and contain growth in certain areas.

Additionally, we have to get away from a reliance on the automobile as our main source of transportation. It is clear that air pollution leads to water pollution.

I teach at the University of Maryland. One day I saw a paper that said 97 percent of our national transportation dollars goes toward roads. Less than 3 percent goes toward mass transportation. That is encouraging the use of automobiles.

I was testifying for our legislature a few weeks ago for low-emission vehicle regulations. I believe we must have those. Yet everybody is saying that it's going to be

the end of the economy if we do that. Nonsense! We clearly should start shifting our priorities.

In Prince George's County we have started a hiker-biker trail network that connects every subway station together so that you can travel from one community to the next without an automobile. That ought to be part of our national policy. There should be requirements and funding to go with that as well.

Q: We work on a high-quality watershed with high-quality resources. We see a barrier in working with federal and state programs to provide funding at the local level for pollution prevention in these high-quality water resources. How can we overcome this barrier in the future? It is important to do so because remediation programs are much more expensive than pollution prevention.

Martha:

At EPA, we agree that pollution prevention is high priority—better than trying to clean up the mess later. People who live in the Great Lakes area may appreciate this more than people anywhere else in the country. While we do need to remediate sediments, for example, that have been contaminated from past discharges from industrial activity, we also need to prevent such contamination in the future.

I agree that most federal and state programs have not focused on pollution prevention. That is a result of our focusing on the most obvious and pressing problems during the past few decades, which mainly consisted of ongoing discharges. Now that many of those discharges have been brought under control, we can see what problems remain and we know that we have to deal with prevention.

I think there are some opportunities in Clean Water Act reauthorization in terms of better regulating industry. But the primary way we're going to deal with prevention is through public education. We must look at the effects of our own lifestyles and think about how our actions relate to the environment—the way we fertilize our lawns, the paints we use, and the use of the automobile. As we change our lifestyle, we must pass our new ethic on to our children.

You've hit on one of the most important issues for the future of the environmental protection effort in the United States and one that I think EPA has recognized and is dedicated to pursuing in the next few years.

Q: In an agency I worked with in the past, only 3 people out of a staff of 120 were field data collectors or biologists in charge of data collection. I have heard that modeling has been called a substitution for manpower. What do you see as a solution to our manpower problem in the future?

Jimmie:

I do think there is a barrier here. Understanding what works and what doesn't work to protect watersheds is a complex question that demands quality information up front. In many cases, we don't have high-quality data.

If you take the analogy of the Clean Air Act, and take the modeling for urban airsheds—meaning federal urban air standards—the one lesson we've learned over 20 years is that our data isn't good enough and our modeling isn't good enough. EPA does have the responsibility to provide resources and tools—dollars—so people can get that data before they begin the process of sitting around the table so they know the mechanisms by which the watershed works. There isn't any substitute for good information in that respect.

Martha:

I hope Jimmie will help us get the funds appropriated!

We need to bring funding from every sector of our economy into these watershed programs. I don't think EPA or any other agency, state or federal, can do it alone.

We need a mix of good monitoring data and good modeling techniques. You can't completely depend upon one or the other. You're not going to always pick up everything you need to pick up when you are in the field. You might not turn over the correct rock. So you need good models as well as representative monitoring data.

We need to be out there more, looking more at the natural resources and understanding more about what we're doing instead of blindly implementing bureaucratic programs.

Greg:

We started out this morning hearing from each of the panelists their visions for watershed management. We then opened up the discussion, and as a group we have

identified quite a few barriers—hurdles we need to overcome. Here are a few that I heard:

- There is a lack of confidence in our government institutions.
- Some federal programs need to be more flexible.
- There are many successful actions being taken around the country, but we have not yet found ways to share our own success stories.
- Changes in personal lifestyle may be necessary to achieve water quality protection.
- We need to find the right balance between regulation—which is necessary to some degree to protect the commons—and voluntary action with citizen involvement.

As you move into your small work groups, I'd like you to consider these three questions:

- What is the most important point that was made today?
- What is the most important point that was *not* made today?
- What are the next steps we need to take?

The panelist's visions were really quite similar, and I would not be surprised if there is a strong common viewpoint among us all. If we can focus on the commonalties, we can leave here today with the beginning of a strategy for achieving our vision. Good luck.

Summary of Small Group Discussions

Visions for the Future

The Visions for the Future panel discussion was followed by breakout sessions—small group discussions held at the conference site and throughout the country. After the breakout sessions, the on-site discussions were summarized by Louise Wise of the U.S. Environmental Protection Agency. L. Gregory Low of The Nature Conservancy moderated an additional discussion and live questions and answers involving the panel, the live audience, and participants at the satellite downlink sites.

Louise:

First, I want to congratulate everyone on the fine work that you have just completed. In a record-breaking 2 hours you all got lunch, broke out into small discussion groups, and with the help of very talented facilitators came up with great information on our common vision and recommendations for action steps! It's really remarkable how similar the responses of all the small groups were.

Now I'm going to try to summarize our findings, and I may need your help. I want to start by listing some of the key words or concepts that were stressed:

- Adaptive management or flexibility.
- Coordination.
- Local empowerment and involvement
- Nontraditional approaches.
- Pollution prevention.
- Education.

Here are some of the points that were most agreed with:

- Let the watersheds breathe.
- Change individual lifestyle—with regard to everything—the way we commute, the way we farm, the number of children we have.
- Educate the young.
- Take into account economic considerations.
- Need national leadership.
- Need to have both a bottom-up and a top-down approach.

Here are some of the points not made:

- Need political will to act.
- Need information about systems—both economic and scientific.
- Need to understand that private property rights carry a responsibility with them.

Most people focused on next steps. I have a nice long list:

- Develop a mechanism to coordinate federal, state, and local efforts, using federal leadership.
- Educate everyone from the President on down about what an ecosystem consists of. Get people out into the environment.
- Define problems using a longer-term vision or horizon.
- Recognize that every watershed has a carrying capacity.
- Take steps to control growth

The on-site discussions were summarized by Louise P. Wise, Director of Policy and Communications, Office of Wetlands, Oceans and Watersheds, U.S. Environmental Protection Agency, Washington, DC. L. Gregory Low, Vice President for Major Program Development, The Nature Conservancy, Arlington, Virginia, served as the moderator of an additional panel discussion. Members of the afternoon panel included:

- Bill (Billy) Frank, Jr., Chair, Northwest Indian Fisheries Commission, Olympia, Washington
- Steve W. Tedder, Chief, Water Quality Section, North Carolina Department of Environment, Health and Natural Resources, Raleigh, North Carolina
- Martha Prothro, Acting Assistant Administrator for Water, U.S. Environmental Protection Agency, Washington, DC
- Jimmie Powell, Professional Staff, Senate Committee on Environment and Public Works, Washington, DC

and urban sprawl. Develop environmentally-sensitive land-use controls.
- Improve the scientific foundation and the flow and organization of information.
- Set national goals and milestones for watershed restoration.
- Set up a clearinghouse. Use a 1-800 number (actually, a 1-900 number so we can take those profits and put them toward our efforts).
- Use existing programs, such as P.L. 566 and others that work on a watershed basis.
- Organize a national watershed forum—like the Wetlands Forum—to jump start and solidify some policy directions for the watershed approach.

And one group voted for a constitutional amendment for watershed protection!

Greg:

Thanks, Louise. That's a challenging agenda for us to tackle. Let's see if we can stress solutions this afternoon. How can we achieve the vision of watershed protection through these measures and others that might be suggested?

Q: I had the opportunity to participate in the Futures Project, which was sponsored by EPA and examined trends taking place in society and where they will lead us in the future. One of the things that came out in those discussions is that our society is organized around a culture of materialism and consumerism—everything is geared toward producing and consuming things. The group decided that we need to change that culture to include a greater spiritualism, a greater respect for the environment and a better stewardship ethic. How do you think that might be brought out?

Billy:

I think that we have to make that change, and it is a social change. The Indian people throughout the Nation have a lot to offer to the American society. We should listen and try to figure out how these principles can be injected into this society.

We can't continue to make paper cups and use them every day, then throw them away. We have to change now, in the next generation and for generations to come. This Earth will heal if we give it a chance.

When we talk about watersheds in 1993, this should be a very positive time in all of our lives. You heard this talk about a new policy that's going to take place from the President on down and throughout all our communities, and you heard that we have a chance. But we're running out of time, so we should take advantage of opportunities today. We have to do it. Nobody else is going to do it besides ourselves.

Q: My group discussed and proposed that we needed a constitutional amendment so that it was every citizen's right to a clean environment. It would deal with some of the private property right issues that we have so much debate over. Is this too outlandish and radical an idea to happen in this century? Is it a totally impractical idea?

Jimmie:

I have a surprising answer: It's the foundation of our common law. We have a tort system that is based on the nuisance notion. I've talked to people from South America, where they don't have English common law. There isn't a fundamental notion of nuisance and the right to a safe and clean environment. So, they've had to enact it from the top-down and try to implement it recently. My view is that our system is already built on that notion.

Greg:

I know that Florida has passed a state constitutional amendment that gives a fairly high priority to environmental conservation.

Q: It appears that we're not likely to find a large amount of new resources. It seems like we're going to have to do things differently given the amount of resources we have. It appears that some traditional programs such as effluent programs, permits and standards will have to change.

Jimmie:

The congressional view is that the best technology standards, the permits, and the provisions for water quality standards that have been built over the last 20 years have been very successful.

There is the problem, as we look to the future. The law expects that waters should be fishable and swimmable. The only sources we can now regulate through federal law are the point sources. Those in-

dustries that have those permits are facing a rationing effect—constantly tighter permits.

I think there are a lot of people in industry who look at watershed planning as a way to break out of that mold. They look at the nonpoint sources and say it's time for them to contribute to the solution. So it's not so much backing away from the success of the current tools as it is adding other tools to deal with the whole picture.

Q: Reauthorization of the Endangered Species Act is overdue. Do you hear anything on the Hill about possible revisions to the Act that might help us address endangered species and preserve biodiversity in general, from a watershed perspective?

Jimmie:

That's a really good question. The act is overdue for reauthorization and, along with wetlands, is one of the most controversial environmental issues in Congress right now. I think the most promising thing that we've heard is that we should restructure the law toward advanced planning so that we don't get to the point where we list species. Instead, we should anticipate problems and manage the ecosystems that support those species long before we need to activate the legal trigger, that is, listing. I know that Chairman Baucus and ranking minority member Senator Chafee (on the Senate Environment and Public Works Committee) are working on legislation that would try to move the Endangered Species Act in that direction.

It's a huge controversy and you can't promise that Congress can deal immediately with things that are controversial. But there are some promising suggestions out there.

Martha:

EPA is very supportive of the act and also of Secretary Babbitt's new initiative to look at species diversity and ecosystem approaches as being the best way to protect species—both endangered and otherwise. We hope to be partners working on that together.

Q: I'm involved with the Kootenai Basin. One issue that you have not addressed is cooperation on an international basis and international standards for watershed management. We feel that more cooperation and standardization from a continental view, rather than a political boundary, will help alleviate the bulk of the northern border's pollution problems.

A final panel discussing their "visions for the future": from left, Greg Low, Louise Wise, Bill Frank, Jr., Steve Tedder, Martha Prothro, and Jimmie Powell.

Martha:

There are some good precedents for approaching international problems. Although we may not have always done it the best way, we have learned a lot from our experience in the Great Lakes region. Perhaps other watershed programs could learn from experiences there.

We're also working hard on the Mexican border, which I'm sure our friends along the Rio Grande are familiar with. It's a very difficult situation. What are our responsibilities there? Do we have our own act together? You talk about standardization on the international level, but in many ways we don't have standardization within our own country. We have different water quality standards from state to state. In the Great Lakes region, we're going to propose new water quality standard guidelines for the states in the Great Lakes Basin in an attempt to move toward standardization. But I think we will make more progress on the international front when we get our own house in order—allowing for some of the flexible management that we need, but with some consistent approaches and principles that we can stand tall with when we deal with our international neighbors.

Q: How do you figure to factor out the interagency "turf" battles that have historically impeded substantive progress in moving forward on environmental issues?

Greg:

Speaking as a staff member of a private conservation organization, I have seen more cooperation in recent months

among federal agencies than I have seen in a long time. So, I think we have a promising environment here to break some of these turf barriers.

Q: One of the images that I'm going to take home from this conference is the abundance of people in this nation that are doing real good work. I'm wondering if it's appropriate for federal and state agencies to recognize and celebrate all the great things that are going on and, in fact, have helped to cause other kinds of positive action.

Greg:

Thank you. Let's give ourselves a round of applause!

Q: I think I'm one of the few citizen groups here, which worries me. One of the concerns I have is that citizens have a lack of faith in the system. They don't think that they can impact the system. Since we've talked about how imperative it is to have a bottom-up mechanism for implementing watershed planning, how can we get people at the grass-roots level involved?

Greg:

There are many success stories in local communities where citizens have secured some important watershed gains. I think we discussed earlier the need to share information and successful case studies among ourselves. The word *communication* has been brought up time and time again.

The private conservation organizations are committed to working at the local level. I hear a renewed commitment at the state and local level to work together. Hopefully, we can reinvent government and make people feel that they do have a voice and do have a say in making things happen.

Louise:

There is one item I forgot to mention that the groups voted for: Everyone in this conference should go home and invite another agency or individual to join the circle so we can multiply the knowledge and efforts. We should take individual responsibility for getting the word out.

There are five notions of reinventing government: government should be community-derived, customer-driven, enterprising, anticipatory, and decentralized. I think we have heard that today, which is really interesting.

Greg:

I would like to add that we have rapidly changing and improved technology. We can link people together from all over the country. This conference would not have been possible just a few years ago.

Q: In the Upper Arkansas Initiative, and regarding private property rights, local citizens are very concerned, very skeptical, and even fearful of government offering them an opportunity to participate in decision making. They're fearful of the word planning. They consider it to be a threat to their private property rights, and especially private water rights. It seems like it's going to take a long time to overcome some of that mistrust.

Steve:

The North Carolina basin project has probably been the most well received program we've ever done—politically, legislatively, and publicly. We have tried to describe the problems and solutions of the basins. We've identified which goals are short-term and which are long-term, so people will not expect miracles overnight. You have to put it all on the table for everyone to understand. But the concept itself has been very well received by the public.

Q: In the West, mining has some very large impacts on the land. Currently, the Mining Act is not for environmental protection but instead for the purpose of advancing mining. Consequently, there are no avenues to regulate old mining sites. What is the future for refining the mining law?

Jimmie:

That's an issue that's been before Congress for 4 or 5 years now. I think that with the new administration, and with Secretary Babbitt's commitment toward reforming the law, changes are likely to be made soon.

Several environmental statutes are up for reauthorization: Clean Water Act, Resource Conservation and Recovery Act, Superfund, etc. But I think that the real progress in Congress for the next couple of years will be on the resource questions—on mining, the way irrigation water is used, on timber sales, on offshore oil and gas drilling, etc. Congress is likely to be more active on those issues than on traditional pollution laws. This is the

period where we are likely to see big changes on the resource side.

Q: With regards to strategies for implementation and sharing our successes perhaps EPA could set up an electronic data base on which we can share our successes. One of the issues that was brought up in session is that local governments need the "know-how" and technology to solve individual problems. Perhaps the federal government could help us establish that data base to share success stories.

Martha:

We've done it. We have it. Bruce Newton over there can tell you how to access it.

Bruce:

We have established a watershed restoration Special Interest Group within the Nonpoint Source Bulletin Board.[1] There is a display at the conference.

Q: The panelists discussed the need for more effective coordination in watershed planning, particularly at the local level. What can I do as a high school student to promote watershed improvement?

Martha:

You might want to get involved with citizen monitoring programs. You can help organize citizen monitoring of the watershed in your area. EPA and states provide information about how to monitor and collect data, which could be used by planners and regulators to help in protecting those waterbodies.

We've also talked about lifestyle changes and good land stewardship. That's something everyone should do. Take the steps that you can—recycle, walk or ride a bike instead of driving—all of these things help to set examples and encourage lifestyle changes among your peers.

Billy:

You can go to your state legislature and start the movement within the state. There are many tools out there that you can use. You have to take a negative and turn it into a positive—and never think negatively. That relates to changing your attitude. You can be a leader in your high school. You can gather information from agencies at all levels of government and help spread the message that we have to change, and we have to do it now.

Greg:

I would encourage you to join the Nature Conservancy or another environmental group. Take action through the private sector. There are many conservation organizations doing many things at the local level. Get your hands dirty, so to speak. Find a real project to work for. Find a real stream to do citizen monitoring on; find a natural area that needs to be saved in a particular watershed. We've had schools where students have raised tens of thousands of dollars for natural-area projects in their watersheds. Make it tangible. Find a project to work on and good luck!

[1] For voice information, call Elaine Bloom at 202/260-3665; to logon to the NPS BBS, call 301/589-0205. The telecommunications parameters are no parity, 8 bits, 1 stop-bit (N-8-1).

Special Presentation

Visions for the Future

The Honorable Mike Espy, Secretary
U.S Department of Agriculture, Washington, DC

I am pleased to have the opportunity to address this conference focused on identifying and solving natural resource problems with a watershed approach. I can't help but think about the logic of watershed management—the logic of taking a holistic approach to address our conservation and environmental concerns. It is the logic of coordination and cooperation. We coordinate the agencies; we reduce paperwork and regulatory burdens. Ultimately, we make our operations more user-friendly.

USDA has used the watershed approach for many years, to the benefit of our farmers and ranchers, both large and small, in our urban and rural communities. There can be no doubt that under the leadership of President Clinton there is a renewed commitment on the part of USDA, the Department of the Interior, and EPA to work together to solve resource management problems instead of creating new problems.

Basically, I believe the watershed approach makes sense in three ways:

- First, it *makes good managerial sense* that is good for government as well as the private sector. The watershed approach is not guided by a particular agency's program, but by the problems that need to be solved and problems that need to be prevented.
- Secondly, the watershed approach *makes good environmental sense.* Water resource problems and water management systems transcend individual farms and other land management units. We need to be using a watershed approach as well as a one-on-one approach with the land user. This kind of approach makes good sense when you consider the nature of nonpoint source pollution. You can't point to a pipe. You can't go to the edge of a stream and point to the problem. But you can measure the impacts of nonpoint source pollution, you can target your efforts to a specific watershed, and you can get the people in that watershed working together on solutions.
- Thirdly, the watershed approach makes *good sense for rural America.* It involves all the people and helps them to understand their impact on their environment. It also helps rural communities protect their natural resources in a coherent, economic way, empowering them to take steps to solve problems.

Although the watershed approach to natural resource management has been in place for a while, there is still much work, coordination, and education needed to be done. In government, we need to work together. We need to develop complementary programs, not competing programs.

I have asked USDA agencies to take a close look at their programs and to redirect them where necessary in order to ensure compatibility with what we're trying to achieve in water quality and water conservation. Agencies must work together and coordinate. The public doesn't have the time, the money, or the patience to tolerate rivalries between government agencies or between government and the private sector.

Further, we have to let sound science and good economics, not a particular program, drive the solutions. We have to keep our programs and delivery systems flexible. We have to set priorities and build new partnerships. We have to be creative and flexible with existing programs and budgets.

As Secretary of Agriculture, I strongly believe that the farmer is one of the greatest friends of the environment. I plan to work closely with farm and ranching groups to ensure that they do not harm the environment. But I also want to ensure that environmental regulations do not harm them under the watershed approach. I think we can all make headway if we keep this in mind.

> "We need to develop complementary programs, not competing programs."

We can have landowners take an ecosystem approach by addressing all the resources—soil, water, air, plants, and animals. We can learn how all the pieces of this environmental "puzzle" fit together.

If we are going to use holistic approaches to solving problems on the land, we have to have more holistic legislative initiatives. We need to challenge our lawmakers to help us get beyond incremental, piecemeal legislation. As we all know, we can all help frame this debate on the reauthorization of the Clean Water Act.

I believe we have to target our water management activities to critical watersheds, with state and local governments having a role.

Finally, for all our resource analysis and economic analysis, we must not fail to recognize where politics and consensus building fit in. We have to involve local leaders. We have to work out our agreements between national and state government, and we have to identify their roles.

I hope this conference is just the beginning of our dialogue on this watershed approach. We certainly need everyone's ideas. Thank you, and have a good day.

Special Presentation

Visions for the Future

Ted Danson, President
American Oceans Campaign

Hello to all the participants of the WATERSHED '93 Conference. We at American Oceans Campaign believe that watershed management and entire ecosystem approaches are critical to maintaining and restoring the health of our planet.

For too long we have been looking at the environment as a big jigsaw puzzle, where different agencies, levels of government, and interest groups try to snap together all the different pieces—one at a time. What often happens is that we run out of money or the project is not completed for one reason or another. Sometimes we find that agencies have been working at cross purposes while trying to solve the same problems. We will likely face many frustrations until we learn that it's all one big picture and in order to make the most efficient use of our time and resources we have to start working together differently.

The time has come for us to see the environment and the individual resources we enjoy as being interconnected. The new leadership in the administration provides us with an unparalleled opportunity to forge ahead at protecting our environment by looking at these issues in a comprehensive manner.

American Oceans works hard at explaining that the world's oceans are all connected—and that what we do on the land ultimately affects our oceans, bays, estuaries, rivers, and streams. The problems affecting these watersheds are often related, and so must be the corrective actions we take to restore these precious resources.

I am sorry that I can't be there to learn from you all in person. Tonight we are celebrating American Oceans Campaign's fifth anniversary; otherwise, I would love to join you. I send my congratulations for your commitment and look forward to continuing our work together.

Special Address

Visions for the Future

The Honorable Carol M. Browner, Administrator
U.S. Environmental Protection Agency, Washington, DC

I appreciate the opportunity to be here with you all this afternoon. It's really quite an honor.

These are issues that are of great concern to me and, I think, some of the most interesting and challenging issues that we deal with in our responsibility for environmental protection.

I am also pleased to be part of this nationwide videoconference. I think this is truly remarkable. The planning for this has been going on for almost a year now, and it seems that the conference is very successful and I think we owe a round of thanks to the organizers of such a successful event—an event that was able to reach out to a broader audience than otherwise could have been involved.

I come to this job from my job in Florida, as head of the Department of Environmental Regulation. I was in charge of a number of projects in Florida to expand environmental regulation to ecosystem protection. I found in my job in Florida that, if you narrowly applied the environmental regulations, while fixing a specific problem and meeting a specific standard you frequently failed to deal with the broader system that you were addressing. I am very committed to moving beyond narrow application of standards and adding to that *ecosystem protection.*

One of the other products of my experience in Florida, and one of the important things that I learned there, is the importance of consensus building—coalitions with business, environmental groups, government agencies, local citizens groups. And I'm very pleased to see that people here today, and those of you joining us from around the country, come from a variety of backgrounds. I think that it is only by bringing all affected parties to the table that we will ultimately be able to achieve what we all know we need to achieve in terms of environmental protection—that is, ecosystem protection.

I know that some of the things that I am proudest of in my work in Florida, in the Everglades, in central Florida in the wetlands, involved bringing all parties to the table and working out very complicated solutions to the problems, allowing growth to occur where appropriate and recognizing that there are instances where growth and its impacts were not compatible and that the system had to come first, it had to be protected.

"I am very committed to moving beyond narrow application of standards and adding to that *ecosystem protection.*"

I look forward to the opportunity at EPA to bring a variety of parties to the table to solve the very difficult problems ahead of us.

The interesting thing about this conference, in addition to the fact that you represent so many different groups, is the role that technology can play, and the fact that we are all joined together through technology. More and more we need to bring technology to the work that we do. That technology can help us to both understand systems and seek ways to protect systems. We can use technology to educate ourselves, to understand why we need to do things in a certain way.

In 1993, our approach to environmental protection involves change and innovation. In preserving our water resources, we must understand the unique characteristics, the unique problems, and the unique set of actions that exist in different watersheds. Right before I came up to the podium, I was

Carol M. Browner, EPA Administrator

looking at a map of the various locations that are joining us by satellite today. And what was so fascinating was that it didn't highlight particular states or counties—here's Florida and here's Georgia and here's Alabama and here's Maine. It highlighted watersheds, systems—here's the Platte River basin, here's the Upper Rio Grande, here's the Kootenai. I think that's an important consideration, to think about it as systems with individual interests as opposed to political jurisdictions.

In addition to our work at the Environmental Protection Agency, there is also work that will be done at a variety of other agencies as we move away from a narrow application of the regulations that are so important to the protection of our environment to a broader understanding of systems. And I might just point out a number of things that are going on in other agencies.

At the Department of the Interior, Bruce Babbitt has already announced that he will adopt an ecosystem approach to the protection of endangered species, and he is putting in place a process to look at the Endangered Species Act that goes beyond the narrow parameters of that law and looks more broadly. Secretary Babbitt has also proposed a biological survey. The nice thing about that is that it draws upon the activities of several other agencies, including those at EPA such as EMAP [the Environmental Monitoring and Assessment Program]. If you look at all of the resources that are being brought to bear across the country, in terms of understanding ecosystems and categorizing biological treasures—everything that's happening from the local government on up to the federal government—you can begin to see that if we brought all of that together in a coordinated manner, our ability to understand and to monitor and map what is happening to these resources would be doubled if not tripled. I really have to applaud Secretary Babbitt for taking a lead and saying it's time—let's bring all of this together, let's bring all the resources together so that we can get the best use of our money and the best information needed for long-term protection.

Another agency getting involved and trying to look at ecosystem protection is the Department of Agriculture. Secretary Mike Espy has announced plans for ecosystem protection for his responsibilities with the forest system. And again, we look forward to working with him and the Department of the Interior and the Department of Commerce in their efforts to make sure that our environment is protected, that our missions are integrated, and that the goals of each of our agencies are ultimately reached.

As we move forward over the next several years, we're going to have many opportunities to take the work that you have begun in this conference and apply it to every single thing that we do. One of the first opportunities will be during the reauthorization of the Clean Water Act. Hopefully, during the reauthorization process there will be an opportunity to talk about watershed protection—to bring the experiences that those of you at the local level, particularly, have gained in terms of looking at the system as a whole. This is something that we have already found members of Congress to be very receptive to and I'm hopeful that we will be able to develop proposals that will be included in the Clean Water Act reauthorization.*

I think what is important about what we're doing, and what we have to work to educate Congress and the public about, is that we are going to move beyond just looking at the trees and look at the forest. We are going to continue our responsibilities in terms of making sure that the standards are being met. But, when we are developing comprehensive plans, we are going to look at how those plans impact the whole system and not just look narrowly, in the way that perhaps we have in the past. We are going to move beyond the pollutant-by-pollutant, medium-by-medium approach, that has been very, very successful. We are going to add something to that. We're going to add our recognition of ecosystems. We're going to add our recognition of the need to protect systems as systems.

The responsibility that all of us will have as we continue in the work that we all do is, I think, very significant. We'll have to take the knowledge that we gain as we deal with the watersheds that we are focusing on now and expand it to deal with the large number of watersheds that we are going to want to deal with.

* Editor's note: The administration's position on Clean Water Act reauthorization is available through NCEPI, 11029 Kenwood Road, Building 5, Cincinnati, OH 45242. Ask for *President Clinton's Clean Water Act Initiative.*

It was very exciting yesterday. I was in Michigan. I visited with the National Wildlife Federation group up there that has done a great deal of work with the Great Lakes. I think there are many more models like that across the country, and we need to take the experience gained from those projects and apply it to all those watersheds that we recognize as being so significant and in need of attention.

I think that inevitably when you seek to do something of this magnitude, it is a change and change never comes easily. But, when we can point to the successes that we already have in terms of this approach, it will make the change that much more acceptable to those who may not be initially inclined.

The other value of this sort of approach is that no two systems are alike, that no two systems face the same problems. That inevitably brings us to an inherent tension that exists in the work that we do that can be resolved on a site-specific basis. The tension I refer to (and those of you who are here from the business community certainly appreciate this) is their need for certainty, for clarity, for consistency; and sometimes that can bump up against the needs of a particular system.

And so we have to make sure that as we develop plans for individual ecosystems we are mindful of the needs of the economic system—of those people who are creating jobs, of those municipalities that have responsibilities in terms of how much they are going to charge their citizens for the services they provide. But, at the same time, we must be mindful of the needs of the natural system. That sometimes means a more complicated process, but one that in the end has much greater returns than some of the other avenues that we may go down.

Finally, I think the significance of this conference is that it presents a challenge to all of us who care about watersheds. There is a need for change—change in the way we manage our businesses, change in the way we run our programs. There is a demand for innovation—for new ways of thinking about the environment and new ways of preventing pollution.

Let me tell you that at EPA we've started down that path. I think that there is a lot of very good work that has begun. And I am very committed to being a part of that and to working to make sure that we are able to do all that we seek to do, that we are open to change and innovation, and that we will meet the unique challenges posed to us as a national agency by America's watersheds.

We are very interested in emphasizing technical and financial support to state and local governments. I would say to those of you who are here from state and local governments that you have in me someone who has a great appreciation for the roles that state and local governments can play in these very difficult challenges that we face. And I believe that you are very significant players in dealing with these kinds of issues, particularly watershed issues.

> "no two systems are alike . . . no two systems face the same problems."

We're also, at EPA, going to work to streamline and coordinate our programs to eliminate duplication and overlap so that we can get about the business of doing that which we really want to do, which is protecting our natural resources.

And, we want to continue to improve our communications with our partners both inside and outside of government—to bring to the table all of those who are affected by the decisions we make so that we can build a consensus and put aside some of the animosity and adversarial relationships that may have existed historically. I don't think anyone believes we gain when we end up in those sorts of positions, whichever side we may take. And our resources ultimately are much better spent protecting, restoring the systems than fighting each other in court or whatever other venue we may choose.

And, finally, I am committed (and I say this recognizing the difficulty), but I absolutely am committed to expanding the number of people who work at the Agency on these issues, and also to bringing others into this fold, including not just state and local governments but the business community, farmers, landowners. I think that there are an awful lot of people who can benefit from this sort of approach who need to be part of it, to see the rewards, and feel like they contributed to making a difference.

I want to close by sharing with you a statement that I read about the Florida Everglades, which has probably been the most significant natural resource affecting me in my lifetime. I grew up very close to the Everglades and I watched it slowly

(well, in some instances, not so slowly) be degraded and impacted to such an extent that there is cause for alarm in terms of the future productivity of that system. I am sure that those of you here from Florida and those listening from Florida are continuing the very good work to restore that system and view it once again as a system instead of all the various parts that it had become.

"this conference has been about . . . a fully integrated perspective of watersheds."

I want to share with you this thought from William E. Odum (BioScience, October 1982): "The ecological integrity of the Florida Everglades has suffered, not from a single adverse decision, but from a multitude of small pin pricks." I think that's true of many watersheds. If you went back and asked what was the problem, you would find that there wasn't one decision that created the problem. It was a series of actions that when taken together made us realize that we had a very significant problem, one that will be very, very difficult to solve but one that we have to solve.

"One key to avoiding the problem of cumulative effects of small environmental decisions lies in a holistic view of the world around us." I think that's what this conference has been about. It has been about a holistic view, about a fully integrated perspective of watersheds. I'm confident that as we leave here today we can carry this view with us in the work that each of us does, and we come from many different perspectives with many different areas of responsibility. But I think that if we can remember that we are trying to protect systems, we can be guided in our work in a more meaningful way and we will be rewarded in the work that we do in a much more meaningful way.

Some of you know this about me, that I have a 5-year-old son, and I have done this sort of work—environmental work—for over 10 years now. But the commitment with which I do this work was radically changed when my son was born 5 years ago. I realized then that, if we didn't make some really significant changes in how we manage our resources in this country and how we respect these resources, my son would not be able to enjoy the natural resources in this country in the same way that I have enjoyed them—that the Florida Everglades would not be there for him, nor many of the other natural resources of the country. And so I think that we not only have to think of the ecosystems that we seek to protect, but also remember that we do this not only for ourselves but for our children and our children's children, so that they can have the same quality of life and the same experiences that have shaped so many of us.

Thank you very much.

Special Guest Speaker

Biodiversity, Rainforests, and BioParks

Michael Robinson, Director
National Zoological Park, Smithsonian Institution, Washington, DC

Today, I hope to set the environmental context for what is happening at this tail end of the 20th century—to explain what is happening in the tropics, what is at stake, and what we may be able to do about it. It is relevant to all of you, because what is happening in the tropics is part of the universal problem that everybody faces in every watershed.

This century has been truly spectacular in terms of change. There's never been anything like it in the history of civilization. Think of it. In this century human populations have tripled, our use of fossil fuels has increased by 12 times, and the world economy by 29 times since 1900. The economic expansion has been so spectacular that in one year alone, between 1988 and 1989, the increase in the world economy—not the total but the increase—was equal to the entire value of the world economy in 1900. If you want a really ludicrous example of how our efforts have proliferated, the pet food industry in the United States is more valuable in terms of money and labor involved than the entire economy of medieval Europe. Just for dogs and cats. That's an amazing fact.

This year and next year, 3 billion people will be added to the reproductive potential of the world—they'll become mature at puberty. So we have this efflorescence of human effort, and in the tropics it is confronting the richest ecosystems on earth. So I'd like to argue that the most significant occurrence in the 20th century is not the end of communism, not the end of the cold war, not any political change, but the impact of one species, *Homo* "so-called" *sapiens*, on the living world. We are using 40 percent of the primary productivity of this planet. One insignificant naked ape has proliferated to that extent.

So let's go quickly through what is at stake. For something like 2 million years human populations were at about at the 5 million level and then, just 10,000 years ago, with the invention of agriculture, we started this upward movement until we are at nearly 6 billion now. The growth of the human population in the tropics has put terrible pressures on the forest. People burn it down for agricultural land to grow crops to sustain the population. The smoke penetrates the cloud layer, creating a phenomenon that is both spectacular and horrifying. This is not the hyperbole of some wild-eyed ecologist. It's real. What we are affecting is the richest ecosystem on earth.

We human beings in the North did the same thing many, many hundreds of years before we started on the tropics. In the 16th century a hundred ships took part in the great Battle of Lepanto in the Mediterranean between the Muslim south and the Christian north. Each of the ships was made of timber, and it took 650 trees to build one ship. The Italian shipbuilders had to go all the way to Spain to find trees that were straight enough. So even in those days the Mediterranean had been deforested.

The same thing happened on this great continent. In what is now the United States back in 1620 there were 170 million hectares of forest. In 1920, the remaining forest covered only 30 million hectares. We did it here for exactly the same reasons that they are doing it in the tropics today.

What's at stake? In 1982 we thought there were 1.5 million species on earth. Then Terry Erwin at the National Museum

of Natural History here in Washington went down to Brazil and Panama and Colombia and studied the number of insect species in the canopy of the rainforest. The canopy is the area 150 to 200 feet above the ground that receives all the energy from the sun—an area difficult to get to. What Erwin did was to fire an insecticidal fogging machine up there, fog the canopy with a knock-down insecticide, cover the forest floor with plastic sheets, and wait for the insects to rain down. Then he did what all good biologists do. He had his graduate students pick the insects up and he identified how many new species of insect they found for each species of tree that they sampled. We know roughly how many species of trees there are in the tropics and you can calculate the total number of species on earth very simply from that calculation. He came up with a new estimate of the number of species on earth—15 to 30 million species instead of 1.5 million. That is as if we had discovered 10 or 20 totally new planets. It's really quite remarkable that we should find that many new species.

The most recent estimate, published in 1992 in *Science* by Paul Erlich and E.O. Wilson, is that Erwin may have been way off. It may be 100 million species, and nearly all of those are tropical. That makes the tropics the Fort Knox of biology, or the Louvre and the National Gallery and the Prado all rolled into one—the richest place on earth. So what we did in the north temperate region when we moved west or into the battles in the Mediterranean was insignificant compared to what's going on now.

In the tropics there are many, many species interacting for the great majority of each year. There is no winter to shut down the theater of life—it's always active. Many of you probably know the glorious Bruegel painting called *Children's Games.* It is a wonderful metaphor for life in the tropics. In the painting you can identify more than 300 children playing more than 70 recognizable games. Just imagine the games that animals and plants play when there are 30 million of them and they have all year every year to play them.

Here are some examples of these complex games.

Bats proliferate in the tropics. There are more species of bats in Panama than in all of North America as far north as Alaska. They eat pollen, they eat fruit, they catch fish. There are fishing bats that I used to see fishing in the locks of the Panama Canal at night. To catch fish at night you need a special sense, you need the equivalent of down-looking radar. The bat actually bounces ultrasound off the surface of the water and distinguishes the ripples that fish make. But, if the bat plunged in to catch the fish in its mouth it would drown. So, it has a huge spur on its hind leg for gaffing fish. Now that's an incredible specialization.

The next one is even more incredible—the frog-eating bat. This bat travels about 60 miles an hour in a power dive toward its prey. Frog-eating bats could exist only in the tropics. In Washington, DC, there are frogs around for only a few months of the year. The rest of the time they're doing what all sensible things do, keeping warm elsewhere, hibernating (a good motto for bureaucrats).

Just consider this. The frog-eating bat finds its frogs by listening for their song, their vocalization. And interestingly enough, only male frogs sing. So this is the ultimate feast of sexual preference. And not only is it only male frogs that sing, but they only sing to attract females—when they are in the height of erotic arousal. So just think of the penalties.

Now, I hope you're getting a picture of the complexity in the tropics. The frog that frog-eating bats most often eat is a little tiny frog, an inch and a half long, which as you might now expect has the most complicated song of any frog on earth because it's a *tropical* frog. It has a two-part song consisting of a whine and a chuck, and each frog adjusts its song when other males are singing nearby. If one male is singing alone it whines, "peow, peow, peow." If there are two males, each of them adds a chuck, so they sing "peow chuck, peow chuck, peow chuck." (I hope you realize that my main specialization is spiders, and I'm not called upon to vocalize very often.) Three frogs add a second chuck, "peow chuck chuck, peow chuck chuck, peow chuck chuck," and four or more frogs add a final chuck, "peow chuck chuck chuck."

The questions any good scientist asks are "Why do they vary the song?" and "Which song is most attractive to the female?" You can test that by playing the frog calls over a loud speaker. That allows you to do all kinds of crazy things. You can speed the tape up and produce a falsetto frog or slow it down and produce a bass frog or play it backwards or add as many chucks as you like because you can

splice the tape, Watergate style. It turns out that the most attractive song is "peow chuck chuck chuck." But males alone do not sing it because there is a penalty for singing such a complicated song—it's easy to locate and, therefore, a frog singing a complicated song is more likely to be eaten than satisfied.

Here's another example of complexity (Figure 1). The famous army ants of the New World tropics are incredible creatures. Up to half a million of them form a swarm. They never build a nest; they march day by day by day, and they bivouac at night in a great heap. They feed on insects as they march across the forest floor. As the ants walk there are some insects that escape by flying upward, and there are flies that hover over the battlefield like fighter planes zapping the insects that escape, and above them there are birds that zap the insects. Those birds are so specialized that there are seven species that are found only with army ants and no where else on earth. They are totally dependent on the ants acting as beaters to trigger the flight of the prey. If you hear birds singing close to the ground in the tropical rainforest, you know that army ants are nearby.

But even more complex and specialized are the camp followers of the army. During the Napoleonic wars, Napoleon's army was surrounded by thousands of camp followers of varying degrees of morality. The army ant camp followers are small insects and invertebrates—some of the most specialized creatures on earth, for example, a mite found only on the jaws of army ants. As the ant sinks its jaws into its prey the mite sips the juices that escape. Another

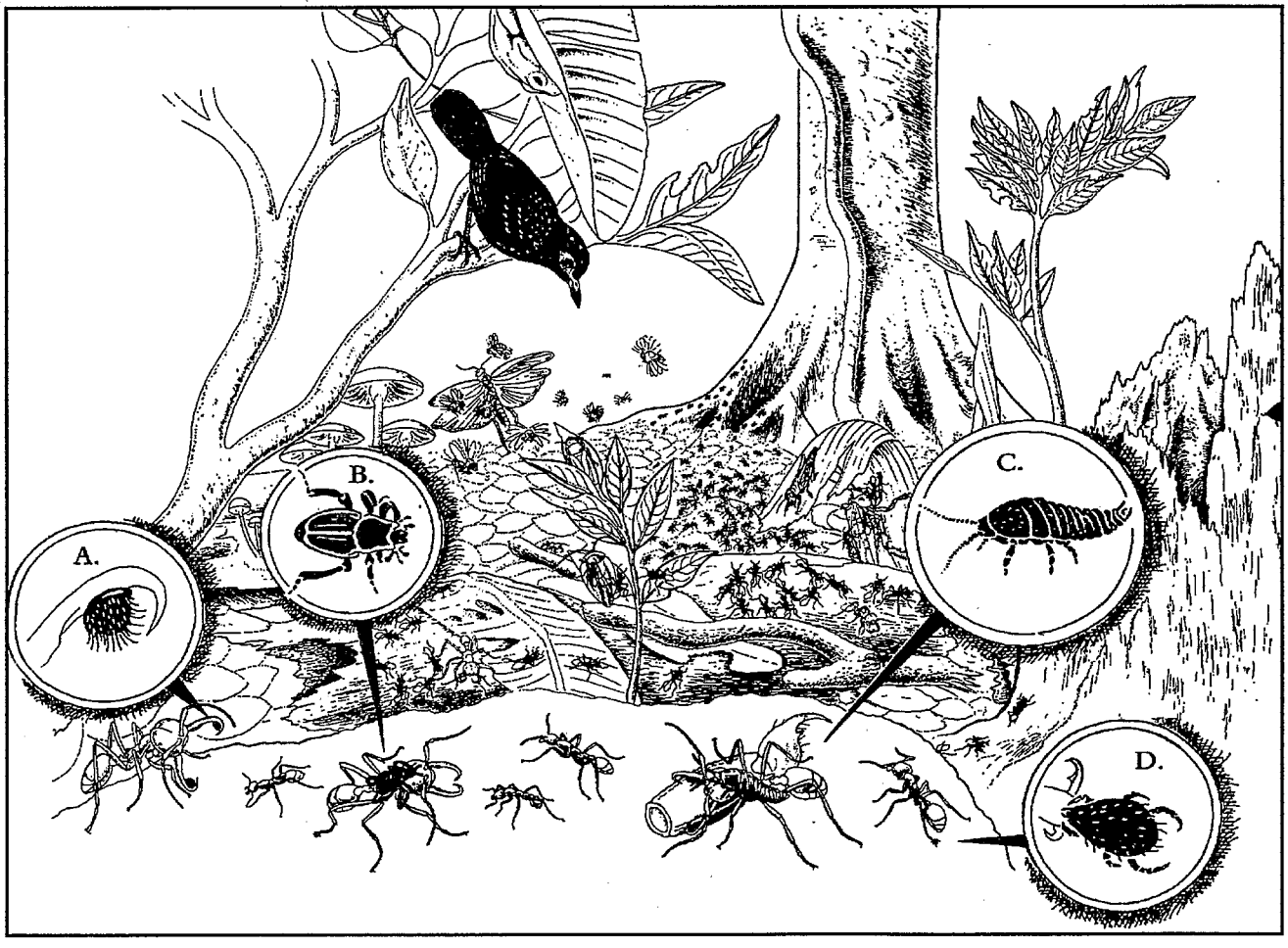

Figure 1. Army ants. The swarm raids across the forest floor, killing and eating insects. Some escape and are eaten by ant birds. Some are parasitized by flies hovering over the swarm. A, B, C, and D are guests of the ants that are attached to workers. A and D are mites. A lives on the jaws of the ants; D, on their feet.

Photo courtesy of Jessie Cohen, National Zoological Park

mite is found only on the soft soles of the ant's feet. What a specialization that is! Sipping softly from the soft sole. An alliteration. And it's thought that that particular mite increases the traction of the ants as they run along. The Reebok.

Here's another case. The three-toed sloth is a wonderful creature. There are 2,500 of them on a little island in the middle of the Panama Canal—slow-moving, gentle creatures without anything but grinding teeth. Their fur is grooved and little green plants, unicellular algae, grow in the fur helping to camouflage the slow-moving sloth. Amongst the hairs there are moths—up to 200 on an individual sloth. Sloth moths.

What do sloth moths do on sloths? They are tied to the inexorable process of the sloth's digestive system. Sloths eat leaves and leaves are full of cellulose, extremely difficult to digest. No human being has a digestive juice to digest cellulose (that's why we can use it as a laxative), but sloths do it by keeping the food in the intestinal tract for up to 10 days at a time. All the bacteria in the gut ferment the cellulose down to starch and sugar. But that affects the toilet habits of sloths. They defecate just once every 7 to 10 days. Imagine being a sloth nurse and having to fill in that chart at the end of the bed: "Bowels moved—no, no, no, no . . . ." Finally, that blessed moment arrives when it descends the tree, digs a hole in the ground, defecates, and covers it up. And the sloth's moths have been waiting for that once-in-a-while event because the feces of the sloth are the food resource for the next generation of moths. So the moths fly off the sloth, lay their eggs on this leaf debris, and fly back. A formerly independent moth has become tied to this host just for that degree of specialization. Sloth feces are the moth's spinach baby food, both in appearance and function.

Here's a floral specialization—the famous Amazonia lily with leaves up to 8 feet across, which you occasionally see pictures of children standing on as if they were boats. When people in Britain built the Crystal Palace for Victoria's jubilee, they modeled the engineering structure of the roof after the venation of the underside of the Amazonia lily leaf because it supports such a large area with such small structures. The flower secretes an odor that smells like decomposing animals. It attracts beetles. When beetles fly in, the flower closes around them and traps them for the night, during which time they mill around and get covered with pollen. In the morning, the flower opens up and liberates the beetles dusted all over with male cells. Then the beetles enter another flower and get trapped again. So, they pass pollen from one flower to another.

My favorite specialization—because I'm a spider person—is a tarantula-like spider that builds a sheet web. Often found sitting on top of its head, looking a bit like a crown or a wart, is another spider of a totally different family. My student, Fritz Volrath, worked out what the little spider is doing, and its a wonderful story of living together. Spiders don't eat solid food. They digest their food, insects, outside their bodies by spreading digestive juices on the prey and then sucking in the digested "bouillon d' insect" that is created. So the little spider is waiting for the host to digest its prey, and then it will climb down its host's face like a rock climber and slurp up the "bouillon d' insect" that the host produced. There wasn't even a name for it in technical scientific language. We got into the literature, past an editor who wasn't really attentive, a new term, *dipsoparasitism*, the drinking parasite. Just marvelously specialized.

Now, I want to highlight the importance of the tropics to human beings. Because of all the specialization and interlinkage, the tropics are the most complex pharmaceutical factory on earth. The struggle for life—the battle for existence is intense, with all the species involved. It is there that we should look for new compounds.

Consider the marvelous tactics of the leaf cutter ant. The ant cuts semicircular

sections of leaves, carries them back to its nest, chews them up, ferments them down into a compost, and then grows fungus on the compost. It's a mushroom-growing ant. It feeds its young and itself on the fruiting bodies of the fungus. They even take the old compost out and dump it in a trash dump. A nest of leaf cutting ants can be the size of the stage I'm standing on. In the nest we have at the zoo you could see all these processes. Eventually, the ants found their way out of the nest through a crack and were dumping their trash down the air-conditioning duct.

Interestingly, some leaves are carried back to the nest and others are rejected. The ones that are rejected have been found to contain fungicides that would kill the fungus garden. These fungicides were not evolved by the plants to kill ant fungus gardens, but to kill the fungus that grows all over everything in hot, wet climates. Because there are more species of fungus in the tropics than anywhere else in the world, it's there that you would expect to find a broad-spectrum fungicide. They tested one of these leaves from a plant called *Hymenia,* and it kills more than 30 different pathogenic fungi. We might have the cure for athlete's foot as a result of studying tropical ants.

This is my last story of complexity. The moth called *Eurania* looks like a butterfly, but it's a day-flying moth. It migrates across the Isthmus of Panama in enormous numbers every few years. My colleague, Neil Smith, found out why it migrated. It feeds on a jungle vine, the leaves of which the caterpillar eats. After three generations of caterpillars have fed on the vine, somehow or other the plant counterattacks and makes something in the leaf that kills the caterpillars. So, the moth has to pick up its population from where the leaves are toxic and fly to a place where they are not toxic. A biochemist at Kew Gardens who studied the toxic leaves found an alkaloid of great potential value (DMDP), a molecular mimic of sugar. It has a hexagonal molecule just like sugar, but it is not a hydrocarbon. It is currently being investigated for its action in the treatment of diabetes. It also is being investigated as a suppressant for feeding in insects. If it is successful in locust control, millions of people who now die of starvation following locust plagues might live. And, because viruses have on the outside of their bodies complex protein coats that pick up sugars, it's being tested in the treatment of AIDS.

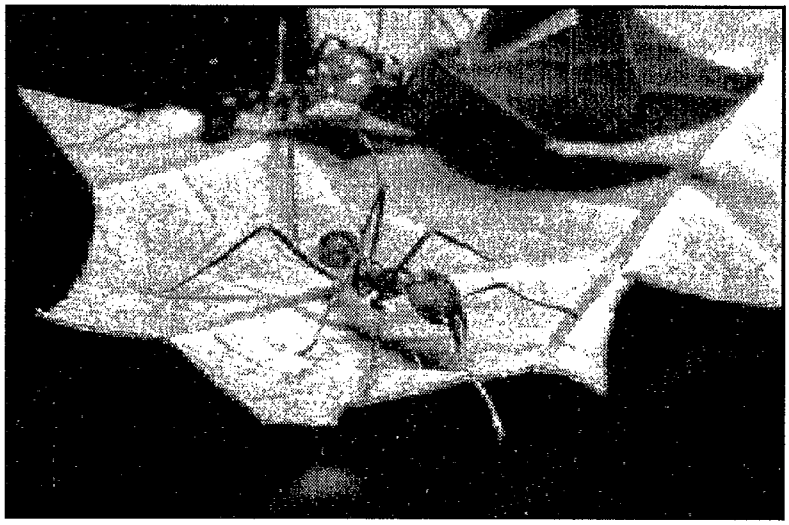

Photo courtesy of Jessie Cohen, National Zoological Park

Now just think. An academic study of a moth in Panama could lead us to all those things. And if you studied leaves from the same plant in areas where the plant had not been attacked by caterpillars, this compound would not be present. So, if you go out prospecting for pharmacological compounds, you need the insight to look where they are most likely to occur.

So, what can we do about saving the tropics? There are many different zoo programs that attempt to save individual species and then maintain them in zoos or, where possible, reintroduce them in the wild. At the National Zoo, we also use the techniques of in vitro fertilization, specifically embryo transplants, to save species. We experimented with domestic cats and have been successful with tigers. The process allows us to affect wild populations where there are genetic problems. In other words, through in vitro fertilization we can increase the gene pool.

In addition to these technical, species-oriented approaches, though, we need to educate people to understand ecosystem concepts and the importance of healthy ecological communities. We need to educate people to care. That is the responsibility of zoos, natural history museums, arboretums, botanic gardens, and anthropology museums. I am suggesting that the time has come to replace the zoological park, where you just see animals, with biological parks where you can learn the biology that every person will need to survive in a democratic society into the 21st century. Biological literacy, I would argue, is as important to this stage of human existence as theology, Latin, and Greek were in the

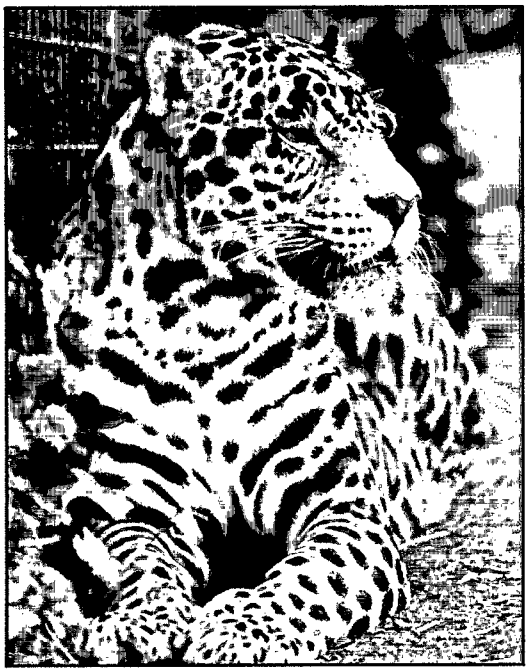

Photo courtesy of Jessie Cohen, National Zoological Park

Renaissance. We really need informal education systems.

At the National Zoo, our new cheetah exhibit describes the problems facing cheetahs. It includes a cheetah trail where kids run along and pretend to be cheetahs. At the end of the trail they can play the cheetah "Wheel of Fortune," where they're asked if they caught their prey or not. This is based on real-life statistics—how many times a cheetah chases prey and how many times it succeeds in catching the prey. It is sobering if you dial the wheel and it comes up "Yes, you caught an impala, but while you were away a lion ate your cubs." That happens, and people should learn about it.

We also built a new rainforest exhibit, Amazonia. The Amazon is the biggest watershed on earth. It pours 11 times more water into the Atlantic Ocean than does the Mississippi/Missouri River system. It is an enormous river with 2,500 fish species alone and 90 million people living in the surrounding rainforest. Those people are destroying the rainforest at an alarming rate and changing the whole climate of South America. At the Amazonia exhibit you can view the environment underwater and then go upstairs to see what the terrestrial rainforest looks like. You develop an understanding of the whole ecosystem.

To finish up, I'd ask you to think about the Bruegel painting again. If you destroyed wantonly that great work of art—slashed it—it would be a crime against humanity. But somebody, a good art student somewhere, could paint a reproduction of it that would satisfy 999 people out of 1,000 and perhaps even convince the one who was an expert. But if you eliminate an animal species like a jaguar, nobody anywhere can ever put it back.

I'd argue that we are on the verge of eliminating beautiful, glorious, important, wonderful, significant animal species on the biggest scale since the Mesozoic when 60 percent of all life disappeared. We can't afford to do it! We have only about 10 years to reverse the trends. When I see a meeting like this, packed with people concerned about the environment, I think there's hope. But there's only going to be hope if you act very, very quickly indeed not just to save the glories of this country, but the other 99 percent of life on earth that's in the tropics. It's in our hands.

Dr. Robinson was introduced by William Spitzer, Chief of Recreation Resources Assistance, National Park Service, Washington, DC.

Watershed Management in Historical Perspective: The Soil Conservation Service's Experience

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The Soil Conservation Service (SCS) early recognized the watershed as the logical unit for organizing one's efforts to deal with natural resource problems. This paper will focus on the lessons from SCS's operation of the Small Watershed Program authorized in the Watershed Protection and Flood Prevention Act of 1954. However, the genesis of ideas about watershed management or protection, as it relates to erosion, runoff, sedimentation, and other watershed environmental issues, goes back to the origins of the SCS. Some understanding of this context is needed.

Hugh Hammond Bennett, a soil scientist in the U.S. Department of Agriculture, became convinced that soil erosion was a threat to future food productivity, and determined that he would work for a national program to address the problem. His crusade to convince farmers to use soil-conserving practices resulted in the creation of a temporary New Deal agency, the Soil Erosion Service, in September 1933, and then the creation of the Soil Conservation Service with the passage of the Soil Conservation Act on April 27, 1935. Earlier, in 1929, he had convinced Congress to fund soil erosion experiment stations to research the nature of soil erosion and to devise means for controlling it.

When Bennett received funds and some Civilian Conservation Corps (CCC) camps for labor in 1933, he decided to concentrate on watersheds near the erosion experiment stations, where he might use the results of the research. The significant lesson is that from the beginning, the early soil conservationists were concerned with the cumulative effects of soil conservation practices on the entire watershed. One of the more comprehensive of these demonstration projects was located in Coon Valley, Wisconsin, near the erosion experiment station at La Crosse. The experience there illustrates the early efforts in watershed management. Between the fall of 1933 and June 1935, 418 of the 800 farmers in the valley signed cooperative agreements. Many of the agreements obligated the SCS to supply CCC labor as well as fertilizer, lime, and seed. Farmers agreed to follow recommendations for stripcropping, crop rotations, rearrangement of fields, and the conversion of steep cropland to pasture and woodland. Alfalfa was a major element in the stripcropping. Farmers were interested in alfalfa, but the cost of seed, fertilizer, and lime to establish plantings was a problem during the Depression. Another key erosion-reducing strategy was improving the soil's water-absorbing capacity by increased use of hay and longer crop rotations. A typical 3-year rotation had been corn, small grain, then hay (timothy and red clover). Conservationists advised farmers to follow a 4- to 6-year rotation of corn and small grain, and 2 to 4 years of hay (alfalfa mixed with clover or timothy).

Grazing of woodlands had contributed to increased erosion. Trampling soil and stripping ground cover reduced the forest's capacity to hold rainfall and increased erosion on fields down the slope. Most of the cooperative agreements provided that the woodlands would not be grazed if CCC crews fenced them off and planted seedlings where needed. SCS also tried to control gullying, especially when gullies hindered

farming operations. While the conservation measures on cropland would ultimately reduce sediment being washed into Coon Creek, streambank erosion was still a problem. The young CCC enrollees built wing dams, laid willow matting, and planted willows to stabilize streambanks.

At the time the Soil Erosion Service began work, Aldo Leopold was on the faculty of the University of Wisconsin and had only recently published his classic, *Game Management.* He convinced the Soil Erosion Service to hire a biologist, Ernest Holt, to improve the wildlife habitat in the watershed. Some feeding stations were established, but generally the schemes to increase wildlife populations were of a more enduring nature. Gullies and out-of-the-way places where the use of farm machinery ranged from inconvenient to impossible were prime planting areas for wildlife. Some farmers agreed to plant hedges for wildlife that also served as permanent guides to contour stripcropping. Insofar as possible, the trees selected for reforested areas were species that provided good wildlife habitat (Helms, 1985).

Silting had reduced the creek's capacity, and sediments during overflows had been deposited on the flood plain. Early in the planning stage SCS requested the U.S. Geological Survey to place instruments on the stream to collect data on how the land treatment measures in the watershed were influencing runoff, erosion, and sedimentation.

Conservation management measures throughout the United States varied according to the type of agriculture, land use, and climatic and geographical conditions. But the Coon Valley project gives us an impression of what we might generally call watershed protection in a farming community where a variety of measures are used to retard runoff, enhance infiltration, and control the movement of water. The term currently used is total resource management. Flood control structures were added later at Coon Creek after SCS received the authorities and funds to build them.

After the passage of the Soil Conservation Act of 1935, SCS began searching for a method of reaching all of America's farmers and settled on the conservation district as a mechanism to bring federal conservation technical assistance to all the Nation's farmers. Thereafter much of the effort of the SCS work was with individual farmers who had become convinced of the value of conservation. There was less focus on concentrating efforts in selected watersheds.

But there were engineering works SCS wanted to install which were too costly for individual farmers, and which often benefited a group of landowners. For instance, the Agency wanted to provide flood control to agricultural lands in the upstream tributaries. SCS had also assumed responsibility within the U.S. Department of Agriculture for giving technical advice to farmers on irrigation and drainage. While the plans were being approved in Congress for large flood works such as the Pick-Sloan plan, the agricultural forces led by the National Association of Conservation Districts and the SCS argued for a program of flood control in upstream small watersheds. The concept combined structures for flood control with the idea of reducing erosion, runoff, flooding, and sedimentation. This was the "watershed protection" part of the program (Helms, 1988).

The Watershed Protection and Flood Prevention Act of 1954 established a mechanism for SCS to work on small watersheds of no more than 250,000 acres. The act originally authorized works for flood control, but it was quickly amended to make other objectives eligible for government financial assistance. As of March 1993, 1,538 small watershed projects have been authorized for installation. Keeping in mind that many projects involve more than one objective, the current total figures for purposes are flood prevention 1,324, drainage 303, irrigation 89, rural water supply 5, recreation 274, fish and wildlife 96, municipal and industrial water supply 169, and watershed protection 236. The major objectives of watershed protection projects are distributed among erosion control 156, water quality 61, and water conservation 9. The SCS often provided technical assistance including engineering design. The local groups had to be organized in a legally recognized body which could sign agreements with the federal government. Federal cost-sharing for some aspects such as floodwater retarding structures might be as much as 100 percent, while local groups might have to provide some of the cost-sharing for other purposes. Typically, local groups were required to provide land, easements, and rights-of-way and to maintain and operate the project.

Local Involvement

Experiences in this program may well provide some lessons for people currently interested in watershed management, especially to those interested in water quality. First, the requirement of local contributions which are necessary for the project to become operational virtually guarantees that the local people have to perceive some value in the project. If this is the case, then the project also benefits from the donated time, effort, and resources, financial and otherwise, of the local community. Decades of debate over cost-sharing rest on this notion that the beneficiaries should help pay if indeed they do benefit.

Understandably, plans for watershed projects which addressed perceived local needs were more acceptable than those written without sufficient attention to local desires. One recent example from the Midwest illustrated how watershed planning teams had best stay in touch with the clientele. In several cases, SCS found that local sponsors rejected designs for dams which, in their opinion, inundated too much of the valuable agricultural land. The local sponsors did accept smaller structures that provided a lesser degree of flood control, but did not require as much cropland for the reservoir areas.

In watersheds with a high percentage of poor people, it is often difficult for the residents to provide their share of the costs; therefore, participation would be low, negating the objectives of the project. In recognition of this fact, SCS's sociologist developed a procedure to justify higher cost-share rates to low-income communities (SCS, 1991).

Working in smaller watersheds also has the benefit of making it easier to identify the beneficiaries of project measures. A small watershed also makes it possible to identify those who may contribute lands, easements, and other goods and services without reaping benefits. This recognition does not always resolve disputes, but it at least helps to clarify the issues involved.

Multidisciplinary Planning

The Flood Control Act of 1936 announced for the first time that assistance in flood control was a proper role for the federal government. To try to avoid the pork barrel odor of congressionally authorized projects, the act stipulated that "benefits to whomsoever they may accrue are in excess of the estimated costs." The ramifications of this provision could hardly have been foretold, and one of the criticisms of the act has been that Congress provided no guidance (Arnold, 1988).

After the passage of the act, social scientists, especially economists, became involved in developing analytical procedures. Overall the "cost-benefit" requirement meant that some planning, not just engineering design, had to be involved. It could easily be argued that earlier planning teams within SCS might have been more multidisciplinary than they were, but this method at least set up the framework to which other disciplines were added later. The environmental movement and the environmental impact statements under the National Environmental Policy Act also worked to broaden the disciplines involved in planning. Other disciplines have become increasingly involved in planning, such as plant scientists, landscape architects, biologists, and sociologists. One of the results of multidisciplinary planning is that the planning team is better structured for working on multipurpose projects.

The addition of beneficial social and environmental justification in project approval, where monetary benefits are not significant, has broadened the possibilities of innovative watershed projects.

Watershed Interactions

The operation of the small watershed program has been important in the history of SCS and the development of soil and water conservation technology in that it forced the Agency to look at the interactions of natural and agricultural systems on the whole watershed. From the beginning, SCS did a great deal of research on processes involved in erosion and the movement of water. Formulating the watershed protection and flood control programs made the Agency begin to examine the interactions of the land use activities with the natural environment. Initially, there was much concern with water and sediment movement. With passage of the National Environmental Policy Act and the Clean Water Act, the watershed-based planning began to incorporate biological and chemical concerns. While the early concerns were about agricultural land, the

development of expertise in small watersheds made it possible to develop hydrology programs for urban storm water management which have been adopted by many small communities.

Flexibility

Public programs such as the small watershed program need both flexibility and accountability. Through the nearly 40 years of the small watershed program, the watershed has remained the basic unit upon which to organize. Over this time, the objectives of projects have changed due to the nature of problems as well as the perceived needs of the public and individuals. During the early stages of the program, farmers often wanted flood control, drainage, and irrigation. Rural communities and towns desired flood control as well as municipal and industrial water supply. The 1960s war on poverty and rural development placed a higher priority on projects that provided jobs, such as those involving recreation. Some of the purposes added to the small watershed legislation, such as wetlands, fish and wildlife enhancement, and water quality, clearly have benefits outside the watershed. One of the lessons of 40 years of operating the program is the desirability of multiple-purpose projects. Such projects are favored for approval over single-purpose projects because they address more needs; fit the idea of holistic, comprehensive, or total resource planning; and are a better investment of public funds. Obviously multiple-purpose planning in watersheds addresses not only the movement of soil, water, and chemicals, but also the economy of the watershed and the whole of the biological resources in the watershed. As a practical matter, such projects draw the support of a larger number of project sponsors, both within and outside the watershed area. This point is especially pertinent to the current interest in water quality. Multiple-purpose projects are more likely to get the support of the local landowning public.

Another lesson from the small watershed program is that a wide variety of project purposes is needed to address resource problems nationwide. Earlier emphasis on flood control, especially on agricultural land, gave preference to certain areas of the country and often excluded communities.

Assessment and Accountability

By formulating a project plan, it is possible to establish a means of assessing whether watershed projects do indeed reap their planned benefits. Nonetheless government agencies have been criticized for seldom, if ever, examining in detail whole programs or individual projects to ascertain the results of their actions and the expenditure of public funds. The criticisms pertain to natural resources areas in general and to flood control projects in particular (White, 1988). There may be several reasons for this attitude. Within the SCS, the main reason has probably been the pressure to use funds on projects rather than audits.

The fact that watershed planning activities focus on a problem and its solution should give us a good opportunity to evaluate individual projects and the program as a whole. Learning in the technical and engineering areas in the SCS has come from safety inspections, investigations of structures after major storms, and investigations of problems. Indeed many advancements in the engineering and hydrologic discipline within SCS are closely related to operating the watershed program. Thus experience results in program revision, but the evaluation we should look at is more in the area of retrospectively assessing the costs and benefits.

As part of the environmental movement there has been a closer look at the assumptions and actions of federal agencies and a general call for assessment of programs. The Soil and Water Resources Conservation Act of 1977 directed SCS to assess the performance of its programs as a basis for improvement and for planning future conservation activities. In 1987, SCS made the most thorough evaluation to date. Based on a random selection, the evaluation captured a reflection of the watershed program's wide sweep as well as its success. The evaluation revealed that actual costs exceeded planned costs by 22 percent, while estimated benefits exceeded planned benefits by 34 percent. Rural community benefits exceeded planned benefits by nearly 200 percent. The evaluation also included assessments of the recorded, environmental and social benefits, which are generally considered nonquantifiable (SCS, 1987). Evaluations should be an ongoing aspect of program administration. The 1990 farm bill directs

SCS to carry out evaluations as part of the program.

There is a clear lesson here for the current emphasis on water quality. At one time the claims of famine, soil erosion, and flood control commanded the public's attention and goodwill. Expenditures in these areas went basically unquestioned. Later there was a demand that public expenditures in these areas be examined and justified. Given the complex nature of water quality and the difficulty of establishing cause and effect, it is reasonable to expect future skepticism. Thus one lesson of the watershed program is to provide a means of evaluating your program benefits early.

Small watersheds provide a means of examining intricate problems and devising innovative solutions. Part of that planning process should include consideration of the historical experience of nearly 40 years of operating the small watershed program.

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A Century of Evolution in Watershed Management in the U.S. Forest Service

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Origins of Watershed Management in the U.S. Forest Service

The U.S. Forest Service began as a watershed protection agency some 102 years ago. I'd like to share some of our experiences as managers of 8 percent of this nation's land base with you today.

From hotly-contested debates of the 1860s in Albany over whether forest lands in upstate New York should be protected from the wanton logging and burning of the times came future leaders of the conservation movement in America. Two million acres in the Adirondacks were legislated into state park status where logging permits would be required and water supply watersheds were to be strictly regulated. Other early conservationists were well aware of these events and undertook the task of protecting as much of the western federal timberlands as possible. There was recognition that scientific forestry could help protect domestic water supplies and ensure a steady supply of water from the mountains for commercial navigation in rivers of the valleys below and for irrigation and milling purposes.

Forest Reserves

Congress debated and rejected many forestry bills until enacting the Creative Act in 1891, which authorized the President to proclaim forest reserves from the public domain. President Harrison acted quickly to sign the act on March 3 and less than 4 weeks later proclaimed the first forest reserve, adjacent to Yellowstone National Park. Soon afterward, the commissioner of the General Land Office directed field agents to seek out recommendations for more forested watersheds suitable for reserve status. The agents' activity was to serve as public notice of the intent to establish a forest reserve. When succeeding Presidents ignored this crucial public notice in 1897 and 1907, Congress reacted by stripping the President of his authority to proclaim new reserves and nearly canceling the existing ones.

In the Organic Administration Act of 1897, Congress provided authorization to move beyond simple protection of the forest reserves from fire, unregulated logging, and trespass to a more proactive administration. This act defined three purposes for which reserves could be established: securing favorable conditions of water flows, providing a steady timber supply, and improving and protecting the forest within the reserve boundaries. Congress rejected language that would have given water use priority to farmers and corporations, choosing to delegate broader powers to regulate land occupancy and use instead.

The reserves were put under the supervision of a federal officer according to rules and regulations established by the Secretary of Interior. Congress transferred the forest reserves in 1905 from Interior to Agriculture. The reserves were renamed national forests in 1907. The rules and regulations for managing the forests were

*Retired since the Watershed '93 conference.

contained in the "Use Book," first issued in 1907. Every ranger and supervisor was expected to carry out its directions. The legacy to this day is "Use but don't abuse" the national forests.

Reclamation Era

The Forest Service had early influence in shaping the Bureau of Reclamation. J.W. Powell's 1878 report on arid lands recommended that the west be divided into grazing and irrigation districts coinciding with natural watershed boundaries. Within those districts, local residents would exercise full control over all the natural resources for their benefit. Many dams and canals would be built. His report did not receive much support, but in 1888 Congress gave him the task of surveying potential reservoir sites and irrigable lands in the arid west. Before his survey could be completed, overwhelming opposition by proponents for creating federal forest reserves and collapse of the Johnstown dam in the spring of 1889 resulted in its termination by Congress. This allowed Congress to focus debate on creation of forest reserves.

Fifteen forest reserves containing over 13 million acres existed by 1893 when a severe depression stopped irrigation development dead in its tracks and with it the call for any more forest reserves. Further water development had to wait for congressional passage of the Reclamation Act in 1902.

Good relationships between foresters and reclamationists assisted the new Reclamation Service in quickly reserving 40 million acres in the West, much of it adjoining the forest reserves. To control the headwaters of the West's streams, and to control its remaining reservoir sites was to control water development. It was a sure way of blocking speculative water filings that could have crippled the national reclamation program in its infancy. Officers in the Reclamation Service also feared livestock interests would monopolize the national forests as they had the public domain, so they helped forest officers regulate livestock use. In 1906, the Forest Service began charging stockmen grazing fees that were considerably lower than those charged on private lands or Indian reservations. The Chief Forester negotiated contracts with livestock advisory boards as a means of cutting administrative costs, ensuring better compliance with grazing regulations and retaining needed support of stockmen. Cooperation between the two agencies suffered in 1908, however, over Forest Service support of sheep grazing on drought depleted ranges. The Reclamation Service wanted sheep removed for watershed protection. The former friendship ended with passage of the Weeks Act in 1911 and the Clarke-McNary Act in 1924, which shifted monies from arid land reclamation in the West to purchase of denuded watersheds in the East for national forests for flood control, navigation, and hydroelectric power.

Hydroelectric Projects Era, 1905-1920

These were also the formative years for the hydroelectric industry, as dam after dam was built on western rivers to serve the growing population and demand for electricity. The Forest Service had to very quickly develop relationships with businesses which sought to control water and hydroelectric power sites for their profit. The high gradients of mountain rivers were highly prized by the power companies, but to build hydroelectric facilities the companies had to obtain special use permits from the Forest Service to occupy and use forest lands needed and pay a modest fee. Fees were based upon a formula that used the benefit of the natural flow of the rivers and their fall, measured in kilowatt hours of energy metered at the powerhouse. Competition for valuable waterpower sites was intense. Before a special use permit could be issued, the ranger had to report on the use fees the company should pay as well as decide necessary stipulations for protection of any roads, trails, or other improvements in the project's path. The Forest Service hired hydropower engineers to help judge the validity of proposed projects, help choose the best among them, and suggest options that promised greater public benefit.

O.C. Merrill was the Forest Service's chief engineer during the World War I era. He was the government's foremost expert on hydroelectric projects and one of the primary authors of the Federal Power Act of 1920. He insisted that approval to build a project should be based on the public benefits to be derived, that preference be given to municipal or federal applications that could equal or better private ones, and

that a Federal Water Power Commission be established to improve coordination among federal departments. As a result, water developments on a larger scale than previously practicable could be considered. Proper management of water resources located on the national forests was a priority for the quasi-regulatory Forest Service of that period.

The Civilian Conservation Corps Era

The national forests were largely ignored by the American people until creation of the Civilian Conservation Corps (CCC) program by President Roosevelt in 1933. By design, the CCC worked on projects that were independent of other public relief programs, which made the national forests and grasslands ideally suited for hosting them. The CCC men fought fires; completed insect and disease control work; built telephone lines, lookouts, trails, roads, bridges, tree nurseries, camp and picnic grounds, and ranger stations; surveyed and mapped; installed soil erosion and flood control measures; and cleared streams of debris. In return, the Forest Service provided men vocational training, high school and college courses, a paycheck, and sometimes a career. The CCC program generated much goodwill, long-lasting benefits still found on the public lands, and local jobs.

Mandates for Cooperation, 1950-1970

The Watershed Protection and Flood Prevention Act of 1954 directed federal agencies to cooperate with states and local entities to plan ways to minimize erosion, flood, and sediment damage through use of soil and water protection measures. Many cooperative river basin planning efforts ensued and a number of flood control reservoirs were designed by the Soil Conservation Service and built by local sponsors with cost-share monies.

The 1960 Multiple Use-Sustained Yield Act directed that the National Forest System be managed for outdoor recreation, range, timber, watershed, fish, and wildlife purposes in a multiple use manner for the sustained production of their goods, services, and values. The Forest Service was authorized to cooperate with interested groups, state and local agencies in the development and management of the national forests. During the 1960s and 1970s the Forest Service hired about 300 hydrologists to help make multiple use surveys and environmental assessments at the ranger district and forest supervisor levels. Watershed restoration, streamflow, and water quality monitoring efforts were greatly expanded by the energetic cadre of hydrologists.

Many of these hydrologists were trained on barometer watersheds where multiple use activities occurred in basins of 30-100 thousand acres and impacts on water yield and quality were measured by networks of instruments. Intended as applied research on a watershed scale, the most significant result of the barometer program was development of the water yield increase guides. These guides were used to plan future timber harvest operations, constrained by the projected increases in runoff from past and present logging, road building, fire, or other changes in forest cover; the inherent stability of the channels; and how many acres were available to be in an "equivalent clearcut condition." This tool was used on many western national forests for project and forestwide planning efforts in the 1970s and 1980s.

Planning Comes of Age in the 1970s

The Resources Planning Act of 1974 (RPA) directed the Forest Service to assess the nation's renewable resources on all forest and range lands and to make comprehensive, long range estimates of present and future uses, demands, and supplies of these renewable resources. The current RPA Strategic Plan, prepared in 1990, calls for the Forest Service to emphasize recreation, wildlife and fisheries resource enhancement, environmentally acceptable commodity production, improved scientific knowledge, and responsiveness to global resource issues like climate change.

The long-term strategy for the management of water, soil, and air resources on the 191 million acres of national forests and grasslands is to improve current resource conditions and protect resource values. Nonpoint sources of pollution are to be controlled through the use of best management practices on all projects and

through restoration of degraded watersheds. Of the 3,128 watersheds comprising the National Forest System, 38 percent were in excellent condition in 1989, 45 percent required no restoration but were sensitive to impacts from major storms, and 17 percent needed capital investments to restore their conditions. Our goal by the year 2040 is to have 53 percent in excellent condition, 40 percent in the sensitive-to-storm impacts category, and only 7 percent needing investments.

The National Forest Management Act amended RPA in 1976 to require preparation of comprehensive 10-year plans, using public input, for allocation of national forest and grassland resources to various uses for production of goods, services, or values. The first set of plans are finished for all 156 forests. Some forests are already starting on revisions and amendments. As a result of this major effort, many thousands of citizens became involved in forest planning to an unprecedented extent; interdisciplinary teams became a standard way of doing business; analytical tools improved; and important relationships with citizens, local officials, agencies, and tribes have been formed. We learned that accounting for goods, services, and environmental quality produced within watersheds is a very sensible approach. We identified changes in expectations, public involvement, process, and implementation of plans that are needed to make planning better. I think other federal and state agencies could greatly benefit from the last 15 years of Forest Service planning. We would be happy to share our learning experiences with you!

Watershed Research

When the Forest Service was first established, all of its units were expected both to manage the land and do research as part of "scientific forestry." In 1908, the first Forest Service experiment station was created at Fort Valley, AZ. It was not long, however, before the conflict inherent in each unit trying to accomplish the dual missions was evident. All research activities were consolidated into a Branch of Research under the Chief in 1915.

The first watershed studies were initiated in 1910 and were on the effects of cutting forests on streamflow at paired watersheds at Wagon Wheel Gap in Colorado and in the White Mountains of New Hampshire. During the 1920s and 1930s, researchers evaluated techniques for rehabilitating watersheds previously degraded by overgrazing and poor logging practices. Major objectives of these studies were erosion control and sediment yield. Other experiments were designed to test ways to increase the amount of runoff that could be achieved by altering tree cover in mountain watersheds.

Much later, watersheds located on the Forest Service's experimental forests became the focus of integrated studies which developed from collaborations of Forest Service and university scientists. These studies combined the work of scientists from a variety of fields, including: ecology, hydrology, geomorphology, ground-water geology, fisheries and wildlife biology, limnology, and remote sensing, to mention a few. The initial impetus for many of these multidisciplinary efforts was small watershed investigations of various land management practices on water quality. These experiments were attractive to researchers interested in ecosystem processes because:

- Monitoring nutrients carried in streamwater from the study watersheds provided an integrating "bottom line" for many linked processes over the whole landscape, including soil chemistry, plant uptake, and ground-water movement. This work became the nucleus of many nutrient cycling studies.
- Whole watersheds could be manipulated and the effects compared with similar, control watersheds.

This combination proved to be very useful scientifically because it provided a new way of answering questions about the response of ecosystems to management practices. At the same time, the use of undisturbed reference watersheds gave insights into natural processes and their effects on the system. This allowed treatment effects to be separated from natural variability.

In the late 1970s, the National Science Foundation (NSF) sought to establish a system of long-term ecosystem studies throughout the country. It examined a number of ecological studies and chose as its model the integrated watershed research being done at Forest Service Experimental Forests at Hubbard Brook in New Hamp-

shire, Coweeta in North Carolina, and H.J. Andrews in Oregon. NSF has subsequently established a network of 17 Long-Term Ecological Research (LTER) sites nationwide, with 5 sites located on the Experimental Forests, including the 3 original integrated watershed study areas. This has been a new approach to funding environmental research for the NSF because this program requires a commitment of at least 20 years. However, this kind of commitment was not new to Forest Service Research. Several of our watersheds have been studied continuously for over 30 years, some in excess of 50 years.

The value of such long records of high quality data to understanding natural trends and processes is immense, attracting scientists from many fields to our studies. The long record of stream water and precipitation chemistry at these sites now provides an excellent basis for judging the effects that gradual alterations such as global climate change and acid rain are having on our forests and streams. The concentration and integration of so many studies in the same watersheds has created a synergistic effect, resulting in literally thousands of scientific papers. The scientific productivity and relative cost-effectiveness of these focused watershed studies convinced the NSF to adopt them for the LTER model.

The Forest Service's integrated watershed studies have some notable achievements:

- At Hubbard Brook in New Hampshire, 1960s' studies of the cycling of nutrients through a watershed led scientists to measurements of the chemical inputs to a watershed via precipitation. As a result, the first long-term evidence of acid rain in North America and that long distance pollutants can be transported from a source were documented.
- Research at the H.J. Andrews Forest in Oregon led to understanding of many of the watershed processes and unique features of the old-growth forests of the Pacific Northwest, including effects of timber harvesting on these ecosystems. It has been a testament to the credibility of our research scientists that their work has been cited by all sides in the recent controversies over the cutting of old-growth forests and the listing of salmon species in the Pacific Northwest.
- A number of landmark studies have been made since the 1930s at Coweeta in North Carolina showing how road construction practices, various conversions of forest vegetation, and forest succession affect the quantity and quality of water in southern Appalachian streams.

Challenges for the 1990s

Recently, the Forest Service formally adopted an ecological approach to achieve multiple-use management of the national forests and grasslands. We will blend the needs of people and environmental values in such a way that these lands represent diverse, healthy, productive, and sustainable ecosystems. Since forest ecosystems change over time whether managed by people or not, our management and care is essential to providing clean air and water, wildlife and fish habitats, and many other values. To make this approach work, the Forest Service pledges to:

- Actively seek out and incorporate your views in our decisions.
- Expand conservation cooperation with state and local officials, the private sector, conservation organizations, or interested individuals.
- Strengthen land manager/research scientist teamwork to ensure the best science is being applied in management decisions.

This new policy on ecosystem management will include four basic principles for management of the National Forest System:

- "Take Care of the Land" by protecting or restoring the integrity of its soils, air, waters, biological diversity, and ecological processes.
- "Take Care of the People and their Cultural Diversity" by meeting basic needs of people who depend on the land for food, fuel, shelter, recreation, livelihood, and spiritual renewal.
- "Use Resources Wisely and Efficiently to Improve Economic Prosperity" of communities by cost-effective production of natural resources.

- "Strive for Balance, Equity, and Harmony Between People and Land" across interests, regions, and generations by sustaining the land community and meeting resource needs now and for future generations.

A second challenge for watershed management will be securing the instream flows needed for resource management of the national forests in the western states. We are involved in eight active water right adjudications at this time and have been filing instream flow and consumptive use claims in all of them. While preparing, filing, and defending many thousands of claims in each basin is costly to us, very time consuming for our hydrologists and fishery biologists, and the results quite uncertain, I believe it is essential work to the mission of the Forest Service.

Closely related is the need to mitigate endangered salmon, steelhead, and sea-run cutthroat trout runs on the Pacific coast. Many of these fish stocks depend upon streams with origins in the national forests. The challenge is to devise effective land management strategies and practices which will enhance and protect the habitats needed for recovery of these endangered fish species. The Forest Service strategy includes designation of key watersheds providing habitat critical for "at risk" fish stocks, identifying and correcting problem riparian areas, maintaining habitats currently in good condition, and restoring degraded watersheds.

In Conclusion

We are primarily land managers, not water managers. For a century now, we have learned that how we administer the national forests and grasslands does have a large influence on water quality, quantity, and sometimes availability. We continue to practice "Use, but don't abuse the watershed" management for the long run. We think our new emphasis on ecosystems is both timely and necessary for getting the latest and best scientific understanding of watershed processes applied on the ground in resolving resource issues.

We want to collaborate with other members of the federal family, the states, local agencies, universities, conservation groups, and the public to resolve water use issues and make our institutions more responsive to the public's strong, abiding interest in the environment. We are halfway toward our goal of having Forest Service liaison staff at all U.S. Environmental Protection Agency regional and headquarters offices. We are active cooperators with state and federal agencies on many policy and scientific issues, but more can still be accomplished. Let's do it!

River Basin Management in the Tennessee Valley

Robert L. Herbst, Washington Representative
Tennessee Valley Authority, Washington, DC

The Tennessee Valley Authority (TVA) is honored to share our experience in river management with you. TVA is recognized as one of the most successful experiments in developing, managing, and conserving regional resources in the world. I sincerely hope that you may benefit from our experience.

Let me make my point right up front. TVA's accomplishments stem from one guiding principle: promoting integrated water resource management to provide the most benefit . . . to the largest number of resource users . . . over the long term consistent with environmental excellence in partnerships with people.

Integrated water resource management is not just a technical exercise. It requires taking a broad view of all the resources in a river basin, sharing data, and providing a mechanism for involving the public in water resource decisions. It involves managing conflict in constructive and creative ways.

My purpose today is to tell you about some of the ways TVA has learned to maximize water resource benefits and manage conflicts.

TVA is one of the world's most famous dam building agencies. Some might say that it has even become a model or inspiration for other agencies around the world pursuing prosperity and development. Having this reputation and history brings with it the burden and responsibility to allow others to benefit from our accumulated experience and knowledge, and to speak out when asked to give some insight or advice.

TVA has a long history, but it is complex, with successes, failures, and some unresolved questions. TVA has been an experiment, but the high purpose of being the first such experiment should be to help others.

The main message of my being here today is to argue that we should never be afraid to reassess our plans. Development is a complex process, and it is always evolving. A paradigm, or way of looking at things, which made perfect sense in the past is bound to be outdated and superseded by new realities and scientific knowledge. So, there should always be a time to review the past with the critical eye of the present and concern for the future.

Let me give you a little background on TVA. TVA is responsible for developing the resources of the 106,000-square-kilometer region drained by the Tennessee River—the fifth largest river system in the United States. This region encompasses parts of seven southeastern states.

We built or acquired 36 dams on the main river and its tributaries, which we operate primarily for navigation, flood control, and hydropower production—the three priorities established by the TVA Act. This water control system tamed the Tennessee River's unpredictable flow, which once varied from a trickle of about 130 cubic meters per second to a torrent of over 13,000 cubic meters per second. It also opened a 1,050-kilometer navigable channel that links the Tennessee Valley ports, by way of an inland waterway system, with ports in 21 states and ultimately with ocean ports leading to countries around the world. And, of course, the system helped generate electric power for industrialization and rural electrification. We are one of the world's largest producers of electricity.

We also try to serve a wide range of secondary objectives—for example, lake level fluctuations for mosquito control,

minimum flow targets near major cities for assimilative capacity, and improved lake levels for recreation. In addition, we protect many rivers which have not been developed. Development is not always necessary or desirable.

Water plays a pivotal role in our region. Our people need and expect an ample supply of good quality water. And in my view, they have a basic right to it. Water is our most valuable natural resource. It is needed for agriculture, industry, and homes. We use it for many forms of recreation. Most important it is *life*—life for the tiniest of microorganisms to humankind itself.

In the Tennessee Valley, water resource managers face a major challenge to make sure there is enough water in the right place at the right time to meet everyone's needs. Sometimes this causes conflict and the need to assess priorities. It also means that some bodies of water—rivers included—need not be developed but left free flowing. Most rivers provide drinking water supplies, fishery opportunities, recreation, boating, and many other uses. Depending on our management, we can provide these many uses or we can adversely affect one or more uses.

In the Tennessee Valley, upstream regions complain that downstream areas get most of the benefits from TVA's reservoir operations. Community leaders in upstream areas—in North Carolina, for example—want TVA to hold summer lake levels higher to promote tourism and recreation. Downstream areas—such as in Alabama—want minimum flows for good water quality. And they are opposed to water uses that interfere with TVA's production of low-cost hydroelectricity. I will talk later about how TVA managed to resolve these conflicting needs through a process of public involvement.

Transfers of water from the Tennessee Valley to other regions are small, but the trend is growing. A major study is underway to the south of us to determine how the city of Atlanta, which will host the 1996 Olympic summer games, can be assured an adequate long-term water supply. I would not be surprised to see them look to the Tennessee Valley for help. But if we provide water to Atlanta, it will be more difficult to allocate water in the Tennessee Valley.

In addition to water supply, people in our region are becoming more concerned about water quality and the ecological health of the water resource. Human activities affect water quality in the Tennessee Valley as they do in your area. Animal wastes, fertilizers, insecticides, soil erosion, and other agricultural sources plus leachate and eroding soil from abandoned mining lands are significant sources of pollution affecting our lakes and downstream areas. Municipal and industrial pollution can cause problems, too, even though these sources are controlled by state and federal regulations.

The Tennessee River is like a common thread tying together the almost eight million people who live in the watershed. It gives the Tennessee Valley its common identity. But, as you may know, the Tennessee Valley is a diverse region. It's divided into 7 states and 125 counties. And it varies widely in topography, as well as rainfall and runoff. These political boundaries and physical differences obviously cannot be ignored. And I want to briefly describe some of the institutional arrangements that have helped TVA overcome them.

When TVA was established in 1933, it was charged with a broad mission in serving the needs of the region. The people who wrote the TVA Act understood the intimate connections between the river, the land, and the economy of the region. One of TVA's first Board members, David Lilienthal, had this to say about TVA's purpose. It was, he said, to develop the Tennessee River Valley "in that unity with which nature herself regards resources . . . the waters, the land, and the forest together . . . a seamless web . . . of which one strand cannot be touched without affecting every other strand for good or ill."

TVA's underlying philosophy is that resources should be developed, protected, and used wisely to meet present needs, but they also must be conserved to be passed on to future generations. A controlling principle of TVA operations is the concept of multiple-use management—use of a resource to meet more than one objective.

Established by an act of Congress in 1933, TVA is not part of any other department or agency. It is a separate government-owned corporation, combining many powers of the federal government with much of the flexibility and independence of a private business. TVA has broad regional authority, which makes us an effective agent of change for developing and managing resources across state and local political

boundaries in the Tennessee Valley region. The TVA Board decides on major programs, organization, and administrative relationships, which allows us to modify our organization and to redirect our efforts quickly as new problems and needs arise.

One of TVA's most important responsibilities is to maximize the benefits of the region's water resource. We have direct responsibility for managing the water control system on the Tennessee River. But jurisdiction over other water resource issues in the Tennessee Valley is shared by many different federal, state, and local government entities. TVA does not—and cannot—dictate change. We must accomplish our management objectives and our water resource development projects *through cooperative partnerships* with other government agencies, businesses and industries, private organizations, citizen groups, and individual water users.

TVA's cooperation with others has been expanded to include interactions *before* and *during* investigation of potential problems as well as after problems have been defined. Before undertaking any major monitoring, analysis, planning, or management programs for an area, TVA now first conducts an *issues* analysis to determine what information is already available from other agencies or organizations *and to determine local perceptions of problems.* This helps avoid needless duplication of effort and often saves valuable time. It also directs attention to problems that might otherwise go unnoticed. An issues analysis usually begins with interviews of officials of State and local environmental agencies, public health agencies, and planning organizations. These interviews seek to identify recent data from various sources, assess local perceptions of water quality related to local use patterns, and identify local organizations and individuals who may have concerns or information about potential problems. Many problems can be addressed and resolved before a project takes place in just this way. And in some cases a decision is made not to build facilities or even to halt construction of facilities once started (often additional facts are uncovered).

However, sometimes analysis and planning before development of a major project is not enough. Major water development projects have the potential for having significant impacts on *social, economic, and environmental* aspects of a community. Those impacts need to be assessed *both before and during the construction process itself.*

Let me give you an example of where TVA involved the public to the enormous benefit of all involved. The public is able to give us more ideas, than we have, document additional facts, and give us their views on values and wants. In *reassessing* our "reservoir operating plan," it was decided to apply the National Environmental Policy Act (NEPA) process to this study. The NEPA process is the law in the United States that requires all federal projects to be assessed for their *social, economic, and environmental impacts and to involve the public in the review.* But using the process for reassessment was our own decision.

It was decided at the outset to apply the NEPA process to this study, so an Environmental Impact Statement (EIS) was prepared in concert with the reevaluation. This decision immediately became a cause of great concern, and understandably so since many decision-makers traditionally have felt that environmental impact assessments required by NEPA are more a hindrance than a help.

However, TVA's experience in reassessing our reservoir operating plan (which we named the Lake Improvement Plan) under NEPA rules demonstrated that the Act helps administrators make better decisions and can strengthen an agency's relationship with the public it serves. By getting all interested parties involved in the process of identifying relevant issues and evaluating alternatives, NEPA promotes creative problem-solving and increases public support for resulting decisions.

This represented a remarkable turnabout. Conventional wisdom had held that additional water quality and recreation benefits could only be provided at great sacrifice to navigation, flood control, and particularly, hydroelectric power production. As things turned out, this was not the case.

It is unlikely that the excellent results obtained from this exercise would have been realized without following NEPA procedures and by vigorously incorporating public input in the entire planning process. In this case, the value of NEPA was in the creation of a "level playing field" on which all participants had an equal chance to voice their arguments and review and challenge the arguments of opposing interests.

The interests of all who use the river system—including TVA's own management interests—were considered systematically and openly. The Lake Improvement Study was conducted in four phases of decision analysis. In each, alternatives were identified, evaluated by TVA staff, and appraised by TVA management *and representatives of river system beneficiaries and user groups.* The scope of inquiry in each phase narrowed gradually to focus on key considerations of importance to the decision-maker. The results of each phase guided the study team in the next phase.

Phase 1 identified major issues to be addressed, which included involving the public as well as TVA's internal analysis.

Phase 2 focused on development of alternative strategies for reservoir operations. Minimum flows were identified that would help ensure improved aquatic habitat while achieving desired lake level improvements. Various schemes for extending higher summer lake levels were investigated to determine what effects these would have on hydropower costs. A key finding was that costs did not increase in a precise, linear way when reservoir drawdowns were delayed until late summer and fall. However, it was found that if summer drawdowns were delayed until September or later, it would be much more expensive than if lake levels were maintained only until August 1.

Phase 3 fully evaluated the effects of the various alternatives on water releases and lake levels. During Phase 3, a newspaper was distributed to the public summarizing the results of the public meetings and internal analyses along with other findings from the first two phases of the study. Additional comments were also solicited.

Phase 4 clarified the decision basis—internally with TVA staff and management and externally with the public. Significant effort was expended to get a clear understanding of the values held by the various stakeholders.

The draft Lake Improvement Plan, in the form of a preliminary draft EIS, was then issued for public review in January 1990. This was accompanied by a newspaper that summarized the draft statement; reported preliminary study results in clear, nontechnical terms; and explained how various factors were balanced to select preferred options and reject other options. This newspaper also announced 12 public meetings at which the public could provide their comments on the draft EIS directly to a top TVA executive (in most cases, a member of the TVA Board).

When the final EIS was completed, a fourth newspaper was published to explain the decisions that had been reached, point out changes made since the draft was reviewed, and thank those who participated in the review.

Following the mandatory 30-day waiting period, the TVA Board formally approved the plan in February 1991. Hearty applause by citizens attending the meeting greeted the decision. Another less vocal indication that the NEPA process had worked extremely well is found in the fact that most newspapers ignored the announcement of the Board's action, or relegated it to a small notice on an inside page. In other words, the controversy that surrounded the issue at the beginning of the study had dissipated; it was no longer news.

This outcome could hardly have been predicted three years earlier when the study began. Based on previous TVA experience, it was more likely that internal stalemate or public controversy would have caused the study to be aborted or would have resulted in a finding that preserved the status quo.

Because the NEPA process was employed so aggressively, the agency's final decision was rendered virtually "bullet-proof." The process had provided numerous opportunities for all relevant interests to express their views—and challenge the views of others—as the decision base was being constructed. This iterative decision-analysis process strengthened both the quantity and quality of the information base, minimizing the chance that critical issues might be overlooked. Too, it allowed for mid-course corrections and kept the focus of the study upon the issues most likely to affect the decision. Conflicts were resolved before documents were prepared and decisions made. Finally, because people are more likely to support a decision in which they were involved, the final decision was readily accepted.

Why was TVA able to use the NEPA process successfully in reviewing its reservoir operating priorities?

- First, the NEPA process was not an add-on to the decision-making process, but was fully integrated into it. Alternatives were developed in concert with all interested river system user groups, and this creative exchange of ideas was used to

develop alternatives which met the needs of the greatest number of river users without risking unacceptable impacts on the system's original operating objectives: flood control, navigation, and power production. True, the TVA study took 41 months to complete, but the time required for so far-reaching a decision was much shorter than it would have been had NEPA not been applied at the very beginning of the planning process. Agencies often spend much time identifying and evaluating alternatives *before* they implement the NEPA process.

- Second, the TVA study addressed all environmental, economic, and social issues rather than avoid the conflicts inherent in these issues. Voluminous and confusing EISs are a symptom of conflict avoidance rather than conflict resolution. The TVA study team focused on addressing and resolving conflicts and presenting findings clearly and succinctly in the EIS. In reviewing its lake operating policies, TVA went beyond the minimum requirements of NEPA. The emphasis was put on external communications, involving the public, and the four-phase decision analysis process.

Since implementing the Lake Improvement Plan, TVA has carefully monitored results and has found no significant problems.

The lake improvement plan is an excellent example of a project that was already operating and functional and was tremendously improved by educating the public to the issues and involving them in the analysis, review, and decision-making process. As a result, the new reservoir operating plan not only benefited more people in more ways, but also improved the goodwill of the public and insured that future projects would run much more smoothly.

What I've described is a relatively new role for TVA and it requires some new skills. We've finished *developing* the water resources of the Tennessee Valley. And now our job is to *manage* the water control system we have put into place.

Where planners and engineers once dominated the agency, now we're relying more and more on experts in facilitation, conflict resolution, and management, and we use the advise of outside organizations and even create advisory groups.

In water resource situations, the playing field is inherently unbalanced. That is, the many different groups with a stake in the water resource do not have equal opportunity to participate in the decision making process. Some interest groups find it hard to get a hearing because they are up against existing laws or because they lack resources or expertise. As a result, change is extremely difficult, and the decision makers do not always make the best decision. At TVA, we've found that creating a level playing field—giving everyone an equal hearing—is crucial to maximizing water resource benefits.

I realize that much of what I've said here today isn't new to you. You understand how water connects people and the land. And you know that conflicts among competing uses cannot be avoided in managing a river basin for multiple purposes.

But I hope you'll take this message to heart. It's based on TVA's 60 years of experience. Water resource conflicts can be solved. There are solutions out there where everyone wins—solutions that maximize benefits for all river system users without degrading the resource or sacrificing anyone's opportunity to use it. They aren't easy to find. It takes time and controversy is inevitable.

But we have been successful at TVA because we have a regional scope of operation and perspective. We have the technologies necessary to manage water flows. We have data from a fully integrated water quality and aquatic biology monitoring system. We have a solid framework for working cooperatively with the Valley states and other federal agencies. And we're getting better at building the coalitions—the partnerships—necessary to solve today's water resource issues with our citizens.

Recently, after 6 years of comprehensively monitoring the water resources of the Tennessee Valley, a colorful and informative publication—*RiverPulse*— has been published to report on the water quality and current status of the entire Tennessee River system annually.

RiverPulse includes an overview of the river's health, answering basic questions: "Is the water safe for swimming? Are the fish safe to eat?" "How healthy is this lake or stream?" Release of the first issue of this report in July 1992 generated

a great deal of public interest with over 1,000 telephone requests for copies in the first 2 weeks after the initial release, and over 60,000 copies being distributed around the Valley, to lake users, marinas, and recreational areas. The publication also contains discussions of some of the concerns facing river managers, such as aquatic plants and zebra mussels, as well as operation information on navigation, flood control, and the benefits of hydroelectric power. TVA's past Chairman John Waters described the effort as representing a milestone in river management. At a recent briefing he said, "With the kind of information in the *RiverPulse* report, agencies and individuals will be able to form grass-roots coalitions and partnerships to take the actions necessary to keep the river healthy and clean."

Looking to the future, we are planning to build an international campus where scientists, business and political leaders, and land managers among others can come to study, learn from each other, and work together to resolve common environmental and economic problems. We hope it will be an institution and process others will want to replicate.

Our biggest challenge is to facilitate management in the gray area between technical feasibility and political reality. That involves flexibility, sharing data, public participation, and a cooperative, open decision process. This is the most important lesson I can share with you from TVA's experience. I think it's vital to overcoming inertia and to creative problem solving in the water resources field.

Let me offer you TVA's assistance. If you think our experience might be useful, we would be happy to help you meet your region's water resource needs or send you additional information.

Evolution of Watershed Planning and Management in National Water Policy

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National water policy initiatives over the last 100 years have considered watershed planning and management as an approach to improve our nation's water programs. Watershed planning and management can occur at a range of geographical scales, from the drainage basins of major river systems to small urban or rural watersheds. At the largest scale, the river basin approach has been an important concept in the evolution of national water policy beginning with the Progressive Era from 1890-1920. Numerous commissions established to study national water policy have recommended a comprehensive, multipurpose, river basin approach to water planning and management along with improved interagency and intergovernmental coordination. During the period from the mid-1930s through the 1960s, however, Congress acted to authorize many large-scale water resources development projects often justified primarily for navigation or flood control.

The federal government began to implement a river basin approach to water resources planning under the Water Resources Planning Act of 1965. River basin planning activities under the act, however, focused primarily on water resources development at a time when public concerns were shifting to water quality and environmental protection. Although the 1980s saw the demise of federal river basin planning, the multiple-objective planning procedures developed to implement the act have continued to evolve and influence federal water resource agencies' programs and policies. The sections below provide an overview of the history of the comprehensive multipurpose river basin approach to watershed planning and management.

1890s-1920s—Emergence of the Concept of a River Basin Approach

The concepts of comprehensive multipurpose river basin planning and interagency coordination were first introduced by several reports under the administration of President Theodore Roosevelt at the height of the conservation movement during the first decade of the 20th Century (Holmes, 1972; Shad, 1989). The 1908 Inland Waterways Commission report and the 1909 National Conservation Commission report recommended comprehensive water resources planning for all purposes (including water pollution control) and creation of a National Waterways Commission to coordinate among all federal agencies involved in water resources activities. A 1912 report issued by the National Waterways Commission made recommendations for coordinating federal water resources development programs, which were never implemented. The 1917 Newlands Act authorized a waterways commission to develop multipurpose water resources development plans; however, the commission was never created primarily because of World War I. Meanwhile, persistent problems with flooding on the lower Mississippi River led Congress to authorize federal funding for levee construction to control flood damages.

The great 1927 flood in the lower Mississippi River Valley spurred reconsideration of the earlier congressional policy to rely on levee construction for flood control. The 1927 Rivers and Harbors Act authorized the Corps of Engineers (COE) to conduct surveys of most navigable streams in the United States, which became the basic river planning documents for the next several decades. Known as the 308 reports, these basinwide plans addressed hydropower, navigation, flood control, and irrigation potential and defined benefit-cost analysis for evaluation of proposed water resources development projects. The 308 reports reflected the shift in emphasis to engineering control of whole river systems rather than targeting flood control measures to the location of flood damages (Rosen and Reuss, 1988).

1930s-1960s—An Era of Large-Scale Water Resources Development

Under President Franklin D. Roosevelt, comprehensive development of river basins was seen as a means to promote social and economic change as exemplified by the Tennessee Valley Authority (TVA). Roosevelt created the National Resources Committee and its successor, the National Resources Planning Board to develop a comprehensive river basin planning and development program (Holmes, 1972; Shad, 1989). These efforts were circumvented, however, when the great floods of 1935 and 1936 in the northeastern United States again turned congressional attention to flood control. The 1936 Flood Control Act established a national water policy focused on structural flood control measures, which were the accepted practice at the time, and began an era of dam building by COE (Rosen and Reuss, 1988).

Tennessee Valley Authority

Under the Tennessee Valley Authority Act of 1933, Congress created TVA during the first 100 days of President Franklin D. Roosevelt's New Deal (Holmes, 1972). TVA was authorized as an independent water management agency with broad powers to manage water resources for navigation, flood control, and hydropower and a mission to promote regional economic development in the Tennessee River Valley. TVA built 20 multipurpose dams on the Tennessee River and its major tributaries by 1953. Although many regarded TVA as a success in promoting regional economic development, attempts to create similar authorities for other river basins in the United States (most notably for the Missouri and Columbia River Valleys during the late 1940s and early 1950s) were unsuccessful.

Flood Control Act of 1936

In a declaration of policy, the Flood Control Act of 1936 stated that flooding is a problem of national significance and recognized that flood control on navigable waters or their tributaries is "a proper activity" of the federal government in cooperation with states and localities. The act authorized construction of flood control projects by the federal government, if "the benefits to whomsoever they may accrue are in excess of the estimated costs." Responsibility for flood control improvements on rivers and waterways was given to COE and responsibility for flood control improvements in watersheds to the United States Department of Agriculture, with no mechanism for coordination between the two agencies. The act authorized over 200 projects, primarily from the 308 reports, with most projects justified for the single purpose of flood control. Even so, by the mid-1930s, federal agencies also considered navigation, hydropower, and irrigation as accepted purposes for federal water resources projects. Cost-sharing requirements specified in the act called for non-federal interests to pay for up to one-half of project costs. To implement the act, COE began applying benefit-cost analysis to estimate the net national economic benefits of project alternatives and made recommendations to Congress about water projects based on the criteria of "national economic efficiency" (Rosen and Reuss, 1988).

The 1938 Flood Control Act authorized additional projects and removed the cost-sharing requirements for flood control reservoirs and channel improvements. Consequently, local interests could obtain federal funds for water resources development projects under an almost 100 percent federally funded construction program. The 1941 Flood Control Act restored the cost-sharing requirements for channel improvements, which in effect gave local interests a bias toward reservoir plans. The Flood Control Act of 1944 authorized numerous

additional projects, including 11 watershed programs as authorized under the 1936 act. The 1944 act also broadened the purposes of federal water resources projects by establishing recreation as an appropriate purpose of COE reservoirs, authorizing contracts for the sale of surplus water for municipal and industrial use, and placing irrigation use of water from COE reservoirs under federal reclamation law. The Water Supply Act of 1958 declared a federal policy to provide storage for municipal and industrial water supplies as a purpose of federal reservoirs. The Fish and Wildlife Coordination Act of 1958 established fish and wildlife management as appropriate concerns of federal water resources management. Although projects could consider multiple purposes, they were not formed or evaluated within an established framework for comprehensive river basin planning and management. Additional major authorizations of flood control projects occurred periodically through the late 1960s (Rosen and Reuss, 1988; Holmes, 1972).

In response to concerns about the costs of federal water resources development projects and the lack of a comprehensive federal water policy, many efforts were made during the late 1940s-1950s to establish a national water policy. The first Hoover Commission in 1949 proposed combining almost all of the federal water resources programs into a single cabinet department to minimize conflicts and centralize decision making. President Truman's Water Resources Policy Commission in its 1950 report proposed interagency river basin commissions with participation by the states that would develop programs for comprehensive water resources development. This report also prompted the Office of the Budget to develop Circular A-47, which was issued in 1957, outlining standards for evaluating water projects. President Eisenhower created a Presidential Advisory Committee on Water Resources Policy that issued a 1955 report calling for the President to appoint a water resources policy coordinator and an independent review board to evaluate water resources project and basin plans, which would be prepared by basin-level committees. The 1955 report of the second Hoover Commission recommended creation of a water resources board in the Executive Office of the President to coordinate agency planning and to establish intergovernmental, interagency river basin commissions. In the 1950s, Congress generally resisted efforts by the Eisenhower Administration to increase cost sharing by local beneficiaries of water projects and curtail federal spending for water resources development programs. Also during the 1940s-1950s, geographers and some other water professionals argued that federal flood control projects along with the trend to greater urbanization had encouraged floodplain occupance and actually led to increases in annual flood damages since the 1936 Flood Control Act (Holmes, 1972; Shad, 1989).

1960s-1970s—The Federal Government Attempts to Implement a River Basin Approach

In response to concerns about the fragmented nature of federal water resources programs, the Senate created a Select Committee on National Water Resources to establish a basis for national water policy. A report to the Committee on water pollution control needs by the Public Health Service introduced the concept of water quality management as a way to meet water quantity needs. The Senate Select Committee's 1961 report recommended that the federal government prepare and keep up-to-date plans for the comprehensive development and management of water resources for all major river basins, improved coordination among federal water programs, periodic assessments of water supply-demand relationships for all major river basins, and grants to the states to stimulate their participation in water programs. In 1961, President Kennedy submitted to Congress a water resources planning bill based on the Senate Select Committee's recommendations and created an interdepartmental committee to study policies, standards, and procedures for formulation and evaluation of water projects. The interdepartmental committee's 1962 report, published as Senate Document 97, directed that project plans should consider multiple purposes and be formulated within the framework of a comprehensive river basin plan (Holmes, 1979). After 4 years of debate, Congress enacted the Water Resources Planning Act of 1965 and the federal government began to implement a river basin approach to water resources planning and to develop multiple-objective planning procedures to guide decision

making for federal water resources programs.

Water Resources Planning Act of 1965

The Water Resources Planning Act of 1965 established the Water Resources Council (WRC) to implement a national strategy for planning for water and related land resources in 21 water regions (Holmes, 1979; NWC, 1973). The act authorized some of the steps outlined in the Senate Select Committee's 1961 report, including preparation of a national assessment of regional water supply and demand, studies of mechanisms for improving coordination among federal water resources programs and policies, and state planning grants. The act began the most notable of the federal attempts to implement a river basin approach to water resources planning under the Title II River Basin Commissions and directed the WRC to establish principles, standards, and procedures for federal participation in river basin planning and for formulation and evaluation of water projects.

The Water Resources Council

The WRC was established within the Executive Branch and the statutory members consisted of the cabinet secretaries relevant to water resources development—the Secretaries of Interior; Agriculture; Army; and Health, Education, and Welfare and the Chairman of the Federal Power Commission. Under the Department of Transportation Act of 1966, the WRC was expanded to include the Secretary of Transportation. In addition to these statutory members, WRC regulations provided for associate members that could participate in WRC meetings, but their concurrence was not required for WRC decisions. Associate members included the Secretaries of Commerce and Housing and Urban Development, and the Administrator of the Environmental Protection Agency. The Attorney General, Chairman of the Council on Environmental Quality (CEQ), Director of the Office of the Budget, and Chairmen of the Title II River Basin Commissions often participated in WRC meetings as observers. Most of WRC's work was conducted by a council of representatives designated by the statutory members; the WRC staff; administrative and technical committees with representatives of members, associate members, and observer agencies; and special interagency task forces (Holmes, 1979).

In implementing the act, WRC's river basin planning and federal policy coordination efforts generally focused on federal agency water resources development activities. However, as noted in the 1973 report of the National Water Commission (created by the National Water Commission Act of 1968 to conduct a 5-year study of National Water Policy), many policy makers during this period were emphasizing the need for a shift in focus from water resources development to water quality and environmental protection. Political support for WRC activities was adversely affected by the environmental movement of the 1960s-1970s, which questioned the justification for major federal water resources development projects. The National Environmental Policy Act of 1969 (NEPA), which required preparation of an environmental impact statement on every major federal action, brought increased attention to environmental quality concerns in federal water resources project planning. In addition, while the Water Resources Planning Act encouraged direct participation by state representatives in the planning process (including Title II River Basin Commissions), lack of representation from local governments and the private sector made it difficult to develop strong local political support for WRC's planning activities. In the 1970s, the number of WRC meetings declined as well as the political support of the Secretary of Interior, who served as Chairman. With the 1980 budget proposal, President Reagan eliminated funding for the WRC.

Title II River Basin Commissions

Title II of the Water Resources Planning Act authorized the establishment of federal-state regional institutions called river basin commissions (Holmes, 1979; NWC, 1973). The Title II River Basin Commissions had no authority to own, construct, or operate projects; to regulate or manage river flow; or to regulate or manage water supply, water quality, or shoreline land use. Consequently, river basin commissions created under the act were planning institutions with no direct powers to implement plans once they were developed. Lack of authority for water management distinguished Title II River Basin Commis-

sions from other river basin commissions created by federal-interstate compacts (e.g., the Delaware River Basin Commission, which was created in 1961) and interstate compacts (e.g., the Interstate Commission on the Potomac River Basin, which was created in 1940).

The President established Title II River Basin Commissions by Executive Order upon written request of the WRC or a state. The act required the concurrence of WRC and at least half of the states in the area, basin, or group of basins involved before establishment of such commissions. If either the Upper Colorado River Basin or Columbia River Basin were to be included in a river basin commission, the act required concurrence of at least three of four specifically named states in the basin. The President appointed the members of Title II River Basin Commissions, which included a chairman, representatives from each federal department or independent agency with substantial interest in the work of the commission, representatives from each state and any interstate compact agencies in the basin, and U.S. representatives from any international treaty organization with jurisdiction in the basin (Holmes, 1979).

Seven Title II River Basin Commissions were established: the Pacific Northwest, Great Lakes, Souris-Red-Rainy, and New England in 1967; the Ohio in 1971; and the Missouri and Upper Mississippi River Basin Commissions in 1972. Thirty-two states were members of one or more of the seven Title II River Basin Commissions. While the Souris-Red-Rainy River Basin Commission disbanded after completing a comprehensive plan, the other six commissions were active until President Reagan eliminated funding for Title II River Basin Commissions in 1981.

Under the act, the statutory duties of a Title II River Basin Commission were to serve as the principal agency for coordination of federal, state, interstate, local, and nongovernmental plans for water and related land resources development in the basin; to prepare and keep up-to-date a comprehensive, coordinated, joint plan for development of the water and related land resources of the basin, including an evaluation of alternative means of achieving optimum development and recommendations with respect to individual projects; to recommend priorities for data collection and analysis and for investigation, planning, and construction of projects; and to foster and undertake studies necessary to prepare its comprehensive plan.

Title II River Basin Commissions were required to submit their comprehensive plans to the WRC, which reviewed them and developed recommendations that were forwarded along with the plan to the President. The President reviewed WRC's recommendations and the comprehensive plan, and transmitted them to Congress with his recommendations. The comprehensive plans typically placed a heavy emphasis on federal water resources development projects.

Principles and Standards

In 1968, under section 103 of the Water Resources Planning Act, the WRC began to develop principles and standards for planning for water and related land resources, which became effective in October 1973. Known as *Principles and Standards* (P&S), the principles were intended to provide a broad policy framework for water resources planning activities and the standards to provide for uniformity and consistency in formulating alternative plans and in evaluating the beneficial and adverse effects of alternative plans. Initially, federal water resources agencies (e.g., the Corps of Engineers, Bureau of Reclamation, and Soil Conservation Service) and federally assisted programs (including the Title II River Basin Commissions) were given the responsibility to develop procedures within the framework of P&S.

President Carter's water policy initiatives of 1978 called for reforms in agency planning because of growing concern about inconsistent use of economic analyses among federal water resources agencies and a lack of attention to environmental values in the planning and evaluation of federal water resources programs and projects. A July 12, 1978, Presidential Memorandum directed the WRC to conduct a thorough evaluation of agency practices for preparing benefit-cost analyses and publish a planning manual that would ensure accurate and consistent analyses among federal agencies as well as compliance with P&S. The memorandum also required emphasis on water conservation and consideration of nonstructural alternatives, which reflected a general shift in accepted flood control practices toward a

greater balance between structured flood control projects and nonstructural management. The shift to increased nonstructural water resources management in national policy had begun early with the National Flood Insurance Act of 1968, which required communities to adopt floodplain regulations to be eligible for federal insurance. The WRC developed planning guidance to assist states and communities in regulating flood hazard areas under the 1968 act. Other changes in policy direction occurred with the Water Resources Development Act of 1974, which directed all federal agencies to consider nonstructural alternatives when considering any project involving flood protection. President Carter's Executive Order 11988, issued in 1977, provided for federal agency leadership in floodplain management for federal lands and facilities, federally assisted programs, and federal water and related land resources planning. Floodplain management, however, is largely a local program (Rosen and Reuss, 1988).

The 1973 P&S was revised during 1979 to integrate water conservation into project and program planning, to require preparation of at least one primarily nonstructural plan whenever structural project or program alternatives were considered, to revise the major decision criteria to place national economic development and environmental quality objectives on a comparable basis, and to incorporate revisions to ensure that benefits and costs were estimated with the best current techniques. In 1980, the WRC made additional revisions to P&S to define environmental quality objectives more specifically. The WRC's environmental quality evaluation procedures for water resources planning integrated into P&S the requirements of section 102(2)(b) of NEPA (which required that previously unquantified environmental amenities and values be given appropriate consideration in decision making by federal agencies) and CEQ NEPA regulations.

P&S was based on multiple-objective planning techniques developed by agency and academic water professionals during the 1960s-1970s (ACIR, 1992; Holmes, 1979). Multiple-objective analysis allowed for evaluation of trade-offs among four accounts: National Economic Development (NED), Environmental Quality (EQ), Regional Economic Development (RED), and Other Social Effects (OSE). These accounts would allow for systematic evaluation of the estimated beneficial and adverse effects on each objective of each project alternative and the "without project" alternative using monetary measures wherever possible. The decision criteria in P&S proposed an explicit trade-off between the NED and EQ accounts. In practice, trade-offs within the scope of economic objectives could be defined by monetary values through benefit-cost analysis, similar to the traditional analytical procedures used for economic justification of projects beginning with the 1936 Flood Control Act. However, it was difficult to evaluate trade-offs for environmental and social objectives in a manner similar to economic objectives because of inherent analytical problems in assigning accurate monetary values to environmental and social resources with no market value upon which to base decisions on benefits and costs.

1980s-1990s—New Directions in Water Resources Project and Program Planning

Under President Reagan, P&S was rescinded and replaced by *Principles and Guidelines* (P&G). Published in 1983, P&G is the analytical method currently used by COE in evaluating alternative water resources projects (ACIR, 1992). P&G calls for various alternative plans to be formulated in a systematic manner to ensure that all reasonable alternatives are evaluated. Like P&S, four accounts are established to facilitate evaluation and to display the effects of alternative plans: the NED Account, the EQ Account, the RED Account, and the OSE Account. However, the trade-off between NED and EQ under P&S was replaced by maximization of net NED benefits "consistent with protecting the nation's environment." P&G has been criticized for placing disproportionate emphasis on national economic development relative to the protection or development of environmental and social resources.

Despite the analytical methods developed for water resources planning under P&S and P&G, some argued that cost-sharing requirements had a greater impact on the planning process. Projects and project purposes tended to be planned and costed to maximize federal costs, in effect, minimizing non-federal costs. These concerns led to efforts to reform cost-

sharing requirements beginning in the 1950s that culminated in the Water Resources Development Act of 1986. Policies established under the 1986 act for COE require greater responsibility for cost-sharing by non-federal interests for both planning and construction of projects.

The Water Resources Development Act of 1990 marks a significant change in policy direction for COE (Nichols, 1991). Section 306 of the act establishes environmental protection "as one of the primary missions of the Corps of Engineers in planning, designing, constructing, operating and maintaining water resources projects." In response, the Corps is redefining its mission to give environmental resource restoration equal budget priority with the more traditional navigation and flood control purposes of its water resources projects and programs. Accomplishing more environmentally sustainable water resources development will necessitate project planning comprised of multiple objectives, the ability to establish regional and national environmental resource priorities, and a mechanism to make defensible trade-offs among economic, environmental, and social objectives as well as among different objectives within these categories. Because multiple purposes and multiple-objective planning were an integral part of federal efforts to implement a river basin approach, policy makers charting new directions in national water policy have much to learn from examining the history of comprehensive multipurpose river basin approach to watershed planning and management.

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Public Law 83-566 and Water Quality

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Many are familiar with how successful the Small Watershed Program (P.L. 83-566) has been over the years addressing flood prevention problems across our country. The Small Watershed Program has been used since 1954 to reduce or eliminate severe damages to our rivers and streams by floodwaters, erosion, and sediment loading. However, there are many other ways to use this unique authority to address all sorts of water resource problems.

Public Law 83-566 is one of the most diverse authorities available to us to accomplish watershed management. It provides an opportunity for water resource development and management under today's environmental and economic climate. And it is more workable than many other federal water resource programs.

First, the program looks at natural resources on a watershed basis (some might say "hydrologic unit," but it's the same thing). We call P.L. 83-566 the small watershed program because it is limited to treatment of upstream watersheds less than 250,000 acres (390 square miles) in size. Many projects are designed for watersheds much smaller than that. This fact alone makes it a valuable tool for solving nonpoint source water quality problems. These issues are more properly addressed on a smaller scale. They are next to impossible to treat on an entire river basin system.

P.L. 83-566 provides authorization to give technical and financial aid to local organizations for planning and carrying out their water resource projects. This is probably the strongest feature of the program. It is a locally sponsored and developed program, not a federal program where government engineers come in and tell the local people what they need. Local people, usually led by the soil conservation district serving the area, initiate a project only after they have determined they have common water resource problems, and have joined as project sponsors to request assistance to solve these problems. Being locally sponsored, corrective measures can be installed voluntarily. The program does not use regulatory authority to get things done.

Under the small watershed program, an interdisciplinary team of technical specialists works closely together to help the local entities develop a total resource plan. They gather data, identify problems, and offer alternative solutions to all identified sources of water resource problems within a watershed area. Soil conservation districts, in cooperation with the Soil Conservation Service at the state, regional, and national levels, maintain close working relationships with federal and state agencies and special interest groups. This is helpful to project sponsors in getting all the "players" together early in the planning so there is a balance between developmental and environmental solutions.

When sponsors have selected the alternatives that best meet their objectives, P.L. 83-566 is one of the best programs available to provide financial assistance for implementing a broad range of water resource problems. Even for those alternatives that cannot be addressed through the authority of P.L. 83-566, the coordinated planning process identifies other available sources of funding.

Although the program has been around for nearly 40 years, it is not an obsolete or outdated program. It has evolved over time with changes made to improve its workability as the nation's priorities have changed. Over the years, planning for development under P.L. 83-566 has included more and more features addressing environmental concerns. In fact,

today P.L. 83-566 projects are being planned where wetlands are being created or enhanced for the benefit of wildlife.

P.L. 83-566 has had a beneficial impact on water quality for many years because of the extensive land treatment applied in upstream watersheds. More recently the program has been used as an excellent tool to specifically address nonpoint source pollution that causes water quality problems. In the 1990 Farm Bill, water quality was added to the Watershed Protection and Flood Prevention Act, providing another primary authority to support water quality improvements.

Although the small watershed program may have historically focused on flood and sediment control structural measures, the program also offers a variety of nonstructural solutions. These opportunities deserve increased consideration in resolving land and water management problems.

Nonstructural Measures for Water Quality

Among the most pressing watershed management needs today are actions to restore water quality and prevent further degradation of surface and ground water. Pollution from nonpoint sources has been shown to be the major cause of reduced water quality. Agricultural activities have been identified as a significant source of nonpoint water pollution nationwide. Erosion, contamination by pesticides and excess nutrients, and runoff from feedlots are primary factors causing degraded water quality.

The small watershed program offers opportunities to address these problems by installing structural measures in combination with conservation practices when these alternatives will provide the least costly way to improve the water quality of a stream or lake.

However, today water quality improvement watershed projects are also being designed and implemented using land treatment conservation practices with no associated structural measures. These are "watershed protection" projects, as indicated by the title of the P.L. 83-566 act. (In the past, watershed protection usually meant applying conservation land treatment measures to the uplands to prevent sedimentation of project structural measures to be constructed downstream.) With this nonstructural opportunity provided under the broad authority of the program, P.L. 83-566 is well suited to address the critical needs to improve the quality of our nation's waters.

P.L. 83-566 and Conservation Districts

The nearly 3,000 soil and water conservation districts across the country play a leading role in this activity. The Watershed Protection and Flood Prevention Act requires land users to apply to their local soil and water conservation district for assistance in developing conservation plans. These plans are developed in cooperation with and approved by the soil and water conservation district in which the land is located. They set forth the types of on-farm conservation measures (some might call them "best management practices") to be applied to the land in order to reduce pollution to acceptable levels.

Since problems and terrain will vary from farm to farm, the plan for a particular farm is prepared in cooperation with the land user. Alternatives are explained and the land user voluntarily selects the ways that will best meet his or her on-farm objectives and reduce the contribution to the overall problem.

Over the years, soil and water conservation districts have provided this kind of on-farm assistance to land users to prevent soil erosion and protect the resource base. There are many success stories about the accomplishments resulting from this land treatment in rural America. The same types of land treatment measures also prevent sediments and related pollutants from reaching streams and lakes improving the water quality.

After approval of the watershed protection project plan, the act provides for financial cost-sharing assistance to land users to encourage them to apply the identified land management systems needed to reduce erosion and runoff from their lands. Usually adequate treatment requires a combination of conservation practices.

Land users are asked to enter into a long-term agreement with one of the project sponsors, usually the soil and water conservation district, to install the planned conservation system. Under the agreement, the land user also promises to maintain the practices. Periodic reviews are carried out by the district to determine

if additional measures are needed to meet the overall objectives of the watershed protection plan.

We believe that this proven program is an excellent tool for meeting today's challenges in watershed management and water quality improvement. There are soil and water conservation districts in nearly every county in the Nation. They are eager to provide the assistance needed to reduce nonpoint source pollution of our waters.

It seems that, whenever a new national concern surfaces, there is a clamor for creating a new program or authority to address it. But you can't beat the experience we've gained over the years using the many and varied authorities available through P.L. 83-566. The National Watershed Coalition maintains that we would be hard pressed to devise a more workable and versatile program than P.L. 83-566 to meet our watershed management needs, today and in the future.

Utility Planning and the Endangered Species Act

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The Lower Colorado River Authority (LCRA) is a self-supporting public utility created by the Texas Legislature in 1934 as a conservation and reclamation district covering 10 counties along the Colorado River. The LCRA harnesses the river for hydroelectric, coal, and gas-powered generation and provides flood control through a series of dams on the Highland Lakes above the City of Austin. Because the Colorado is a major source of drinking water, LCRA works with local governments and volunteers to improve water quality and water conservation practices.

Revenues are generated by wholesale electric and water sales and user fees. The LCRA provides electricity to 44 wholesale customers including 33 cities and 11 cooperatives. These customers serve over 1,000,000 Central Texans and 42,000 businesses and industries over all or part of 55 counties. The river supplies the water necessary for the operation of LCRA power plants, the Southwest Texas Nuclear Project, and more than 100 municipalities, water districts, and private water systems. It also is the source of irrigation for rice growers in Matagorda, Colorado, and Wharton Counties.

The wide variety of topography, soil types, and rainfall rates in the LCRA service area produces a diversity of habitat types ranging from the Cross Timbers and Prairies vegetation area in north central Texas to the Gulf and Marshes vegetation area on the Gulf coast. The federal Endangered Species Act (ESA) affects almost every operational aspect from electric operations to the acquisition, disposition, or use of land assets. This is true not only of major new construction projects but routine maintenance and operations of electric transmission and distribution facilities, substations, hydroelectric facilities, parks, and open space areas. Under the leadership of a new general manager, the LCRA faced the fact that the ESA had basically, up until that time, been ignored and compliance action would have to be initiated immediately. It was quickly decided that virtually no acquisition, disposition, or manipulation of LCRA assets could occur without consideration of the ESA and all activities were frozen.

A senior staff person was assigned to head a team to assess compliance options and prepare a work plan for implementation. The first thing that occurred was a hurried trip to the U.S. Fish and Wildlife Service (FWS) Regional Office where mercy and assistance were requested. Numerous key players and participating agencies in the process were identified in order for LCRA to be fully informed and effective. An assessment of the potential impact of all LCRA proposed and ongoing activities on threatened and endangered (T & E) species and their habitat was initiated by LCRA staff biologists, land managers, and project engineers. This was not going to be a quick and easy task.

It was determined that both a short-term and long-term approach would be necessary. The short-term strategy of compliance on a project-by-project basis would facilitate the continuation of day-to-day operations. Projects which were already ongoing or immediate in nature were identified and a priority assigned for habitat surveys to be conducted beginning in April 1991. The top-priority projects were those which occurred in geographical areas identified as warbler and vireo breeding habitat due to the time constraints associated

with the breeding season (February through June). Contacts were made to identify procedures already approved by FWS in order to facilitate immediate survey needs. A wildlife biologist was hired and an outside services contract executed for additional support to relieve the immediate logjam of required surveys. Project employees have been added as needed. It must be noted that due to the number of projects to be evaluated, this was no small task in the time allotted.

The process of "project-by-project" evaluation appeared deceptively simple because none were found to be in violation of the ESA. But, realistically, because of the numerous T & E species in the LCRA service area, development of a long-term comprehensive approach to habitat management is necessary. Using short-term project reviews as building blocks, a reliable and current data base is being developed based on systematic biological assessments. After thorough analysis of this biological data, a determination will be made of various species specific regions and their natural geographic boundaries. Management practices will be identified and implemented to restore, enhance, or create biological ecosystems that prevent, when possible, further species extinctions and assist in recovery of designated and endangered species while nourishing existing flora and fauna. It is intended that LCRA will treat T & E species survival and recovery as an integral component of all ecological assessments and habitat management plans, rather than as an isolated issue. Such practices not only contribute to the quality of life but are a vital component in the cost/benefit analysis of future LCRA business activities. It is estimated that these objectives can be completed by Fiscal Year 1999 in conjunction with Austin Ecosystem 2000.

The concept utilized by LCRA to implement thoughtful and integrated habitat management was the establishment of an Environmental Assessment (EA) Team to take the lead on coordinating and tracking projects. This team is composed of wildlife biologists, geologists, archaeologists, hazardous materials experts, and other environmental staff who become involved depending on the particular project characteristics. A consultant works with the EA Team in order to conduct the biological assessment of the LCRA service area in a shorter period of time. In addition, a basic survey document concerning an individual project is now required to be submitted by the project manager to the EA Team as part of the planning process of every new project. This document provides baseline environmental information which is reviewed and field verified by the EA Team. To date, no LCRA activities have required an ESA permit; however, since February 1991 LCRA has consulted with FWS on the numerous projects—some were cleared and some required modifications but none were stopped. In addition, LCRA has worked with FWS to develop procedures for routine and overhaul maintenance of their transmission and distribution lines and procedures of emergency operations when life threatening or system emergencies occur. The LCRA endangered species program has been under development for several years now and is focused on the main goal of conducting business in such a manner that an incidental take is never required.

The T & E species that are currently listed within the LCRA service area are numerous. The most famous Central Texas T & E species are the black-capped vireo and golden-cheeked warbler. The black-capped vireo is widely distributed as a breeding bird within the LCRA service area, nesting in brushland usually dominated by deciduous shrub and tree species ranging from 1-10 feet with foliar cover to ground level. This type of scrubland habitat generally occurs on poor, rocky soils, slopes, gully edges, ravines, and floodplains of usually dry washes. The black-capped vireo primarily nests in rights-of way (ROW) in western Travis County and adjacent areas. Removal of vegetation in known or suspected vireo habitat is strictly prohibited during the breeding season—late March through September. Minimal disturbance of potential habitat during other times of the year, when the vireo is absent, may not pose a serious threat but large-scale activity is generally avoided.

The golden-cheeked warbler primarily inhabits late successional Ashe juniper/oak woodland on broken terrain including steep hillsides and canyons in a number of counties west of Interstate 35. Any activity that removes vegetation or introduces edge into habitat during breeding season (February-June) is assumed to have a detrimental effect on the warbler and is avoided.

There are many other T & E species throughout the LCRA service area. There are four plant species—Texas wild-rice, Texas snowbells, Tobusch fishhook cactus,

and Navasota ladies' tresses. The greatest threat to these T & E plant species occurs from the clearing and construction of Transmission and Distribution ROWs, ROW maintenance, removal of slope vegetation producing slope erosion and undercutting tree roots on slopes potentially providing habitat, pesticide/herbicide use, and addition of sediments and pollutants to existing water courses. A single Tobusch fishhook was located in a survey for a transmission line and, through an informal conference with FWS, agreement was reached to cage the cactus during construction and mark it for future identification. Also, our general approach to nonpoint source and integrated pesticide management prevent flora damage.

There are five T & E cave-inhabiting arthropods—Tooth Cave pseudoscorpion, Tooth Cave spider, Tooth Cave ground beetle, Kretschmarr Cave mold beetle, and Bee Creek Cave harvestman—which are restricted to limestone caves developed in the vicinity of Austin. Removal of vegetation above a known cave is avoided, vegetation removal in areas of cave-producing geologic strata minimized, and use of pesticides, herbicides, and fertilizers prohibited in these areas. Construction was recently completed of the new general office complex located in west suburban Austin on the lake. A sink hole existed on the site that had to be checked. A cave digging specialist was employed who found a cave at a depth of 18 feet, but the fissure for entry was not to be opened short of dynamiting. That seemed counterproductive so the cave was baited. Only fireants came to eat and so it was determined the project could proceed.

Three endangered fish species also occur in the LCRA service area—San Marcos gambusia, Fountain darter, and Clear Creek gambusia—all restricted in range to spring-fed headwaters of streams or rivers. Runoff from construction sites, potentially increasing water turbidity and carrying material toxic to fish life, is a potential hazard to these species. Clearing of vegetation in the floodplain near the headwaters of these river or streams should be avoided. Of course, when nature decided to bless us with the Christmas Flood of 1991—which was the worst weather event in the history of the river, managing the headwaters of rivers and streams was virtually out of control relative to endangered species.

The Houston Toad is located in a limited number of counties but local impacts from planting improved grasses, small-scale clearing, or highway traffic have long-term detrimental effects on the species. One solution employed by the Department of Transportation (copied from an English concept) is a toad tunnel. Two endangered salamanders—the Texas blind salamander and the San Marcos salamander—inhabit subterranean aquatic environments under the City of San Marcos in the vicinity of the headwaters of the San Marcos River. The Concho water snake, which inhabits the Colorado and Concho Rivers, is vulnerable to sedimentation and pollution. The American alligator resides only in Colorado County and the wetland areas supporting alligator habitat. In most cases, these habitats are spanned or avoided when situating electric transmission lines and structures. One endangered mammalian species, the ocelot, may range into the LCRA service area in Karnes County where it inhabits dense, thorn-scrub thickets.

Winter T & E visitors to LCRA are the whooping crane, piping plover, interior least tern, and Arctic peregrine falcon which occasionally nest or forage in ROWs or along the coastlines on beaches, mudflats, islands, or sandbars. In addition, sometimes the larger birds collide with transmission lines. Experimentation with different types of line markers is being evaluated to see if flying fatalities can be decreased. Bald eagles nest in southern counties, migrate throughout the service area, hunt primarily over aquatic habitats, and construct nests near water. Electric transmission facilities are routed to avoid bald eagle nests. The Attwater's prairie chicken inhabits tall and midgrass coastal prairie, and potentially occurs in six counties. Habitat loss is the main contributor to their decline as it is converted to urban uses, cropland, or "improved" rangeland. The red-cockaded woodpecker may occur as a year-round resident along LCRA wholesale customer lines and pinelands in Montgomery County. Nest cavities are excavated in living pine trees and the pine sap flows from the hole. This leaves gummy extrusions of sap below the nest identifying its location. Clearing and construction activities have been avoided around trees with nest cavities.

Should the existence of any of the above T & E species and their habitat be confirmed and project requirements not be suitable for modification, an incidental "take" (a take related to the incident or occurring as a result of proceeding with the

project) will most likely occur. Then, and only then, will the permitting process be initiated and the following options considered:

1. Cancel or relocate any project requiring a "take" and avoid permitting process.
2. Continue on a project-by-project basis utilizing federal involvement for section 7 permits when possible and otherwise avoiding an incidental take.
3. Pursue section 7 permits when federal involvement, and use section 10(a) permit for any remaining projects which must be completed.
4. Pursue one section 10(a) Regional Permit for entire service area.
5. Pursue several Regional 10(a) permits which are species-specific.
6. Participate in a proposed habitat conservation plan with the appropriate governmental entities and utilize a combination of section 7 and section 10(a) permits for the balance of the service area.

There are several practical problems which are under consideration in the long-term planning process. These collateral questions will need to be discussed with FWS before LCRA develops a final comprehensive habitat plan. The problems include:

1. Most of LCRA's excess lands are located in Travis County and consist of warbler and vireo habitat. These lands would not likely be available to offset an incidental take of toad habitat or other species habitat.
2. Since most of the excess land is located in Travis County and Travis County may be included within a separate regional 10(a) application, it is not clear whether such land would be available to LCRA to offset activities conducted in warbler and vireo habitat outside of Travis County. Conservation guidelines, published by FWS state that individual permits located within the boundaries of a regional conservation habitat plan expire upon adoption and approval of the regional plan. Hopefully, this restriction is limited to LCRA land, if any, actually included in the regional conservation plan and does not extend to all land encompassed within Travis County. Under the most advantageous interpretation, however, LCRA would not be able to include land encompassed within the regional conservation plan in its own individual 10(a) permit.
3. For those activities involving electric utility lines or other lands which LCRA does not own in fee simple, only mitigation of such activities can be provided. Such land can not be included in a conservation plan since we cannot guarantee that the lands will be "managed" by the fee simple owner or third parties unless we acquire conservation easements from the landowners, or they agree to participate directly in the permit application. Therefore, if mitigation of our transmission line activities is not sufficient, additional acquisition of species specific habitat may be our only practical alternative.
4. In the event that LCRA designs a permit application area large enough to encompass the activities of its customers, some consideration will need to be given as to how LCRA should propose to guarantee mitigation of such activities if it does not have a property interest in the land where the activity occurs. The mitigation requirement may be satisfied through submission of an agreement between the customers and LCRA, or it may require participation by LCRA customers in the permit application.

Of major interest to LCRA is the beneficial water quality aspects of the ESA. Ground and surface water quality can be protected and enhanced by a comprehensive regional plan as it provides protection from nonpoint source water pollution. For example, the region identified as being critical habitat in Travis County includes part of the Barton Creek watershed which is not protected by either LCRA's Non Point Source Pollution Ordinance or the City of Austin's Watershed Ordinance. Regional plans could provide an opportunity for protecting larger areas of land under Habitat Conservation Plan (HCP) guidelines.

Mitigation is a requirement of both section 7 and 10(a) permits. Various creative strategies have been developed by the Environmental Assessment Team should either permitting process become necessary. Such strategies include one for one land swaps, cash to purchase replacement habitat, habitat enhancement on other land parcels, research on T & E species such as botanical

farming, artificial insemination, comprehensive recovery techniques, and public awareness and education activities.

Another major effort was obtaining support for the tenets of the ESA from LCRA field crews and staff. Most of the crews would just as soon shoot a T & E species than worry about it—particularly little bugs and two birds. One method that was used was to sponsor an Endangered Species Forum for the general educational purposes of LCRA staff and wholesale customers. Over 23 nationally recognized authorities in this area spoke at the Lyndon Baines Johnson Auditorium on the University of Texas campus, over 600 attended, and open public debate occurred on ESA and HCP strategies, mitigation alternatives, and other policy alternatives. The Proceedings of this Forum have been published and distributed. The next step was to provide staff awareness training to increase sensitivity to the general principles of habitat management. This has been somewhat accomplished by conducting orientation sessions presenting general concepts of habitat management and identification of threatened and endangered species at field crew locations. An educational manual and videotapes are used on public TV, in public presentations, and staff training for LCRA and other organizations.

In conclusion, implementation of the federal ESA requires vision and leadership. It requires LCRA to work with other community leaders in order to advance the issues to a higher level of public debate and to aggressively move to combine our endangered species problem with other related issues such as a comprehensive regional water quality plan and the provision of recreation and open space.

Some view the ESA as a conspiracy to stop economic growth while others truly believe that biodiversity and balanced, well-managed ecosystems are the key to survival. The latter see the ESA as one of the purest statements of the environmentalist ethic and a powerful weapon against further ecosystem destruction. There are some problems which will require a series of compromises. The ESA affects fundamental property rights, contains inconsistencies, and has not always been uniformly enforced. Like many other environmental laws, it has its good points and bad points.

The position LCRA has chosen to take is that the ESA provides an extraordinary opportunity to serve as a catalyst for creating a world-class model of economic growth, prosperity, and environmental protection. The LCRA has made it a point to create partnerships with FWS and the Texas Parks and Wildlife Department in order to meet the challenge of ESA. All it takes is time and money, and these are certainly scarce in today's economy, but it is a unique opportunity to provide significant protection in the water quality of several areas of hydrologically and ecologically critical western watersheds, all of which have tremendous scenic and recreational value.

Baltimore County Regulations for the Protection of Water Quality, Streams, Wetlands, and Floodplains

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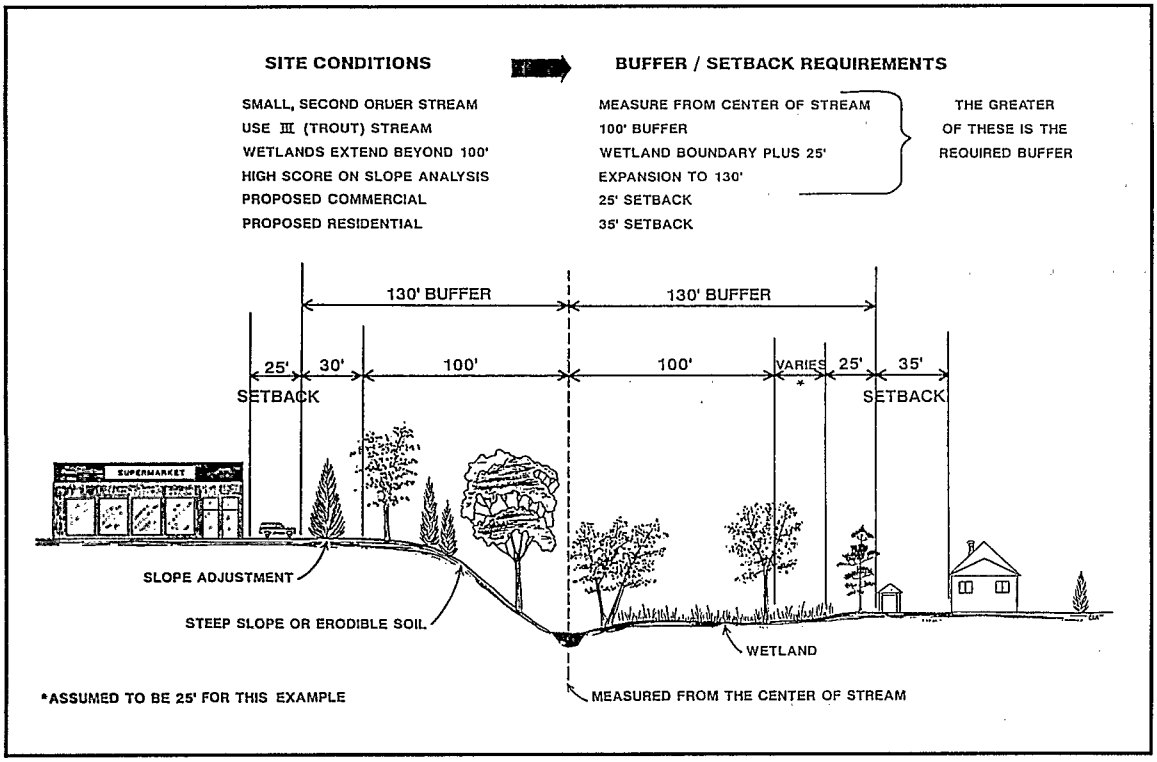
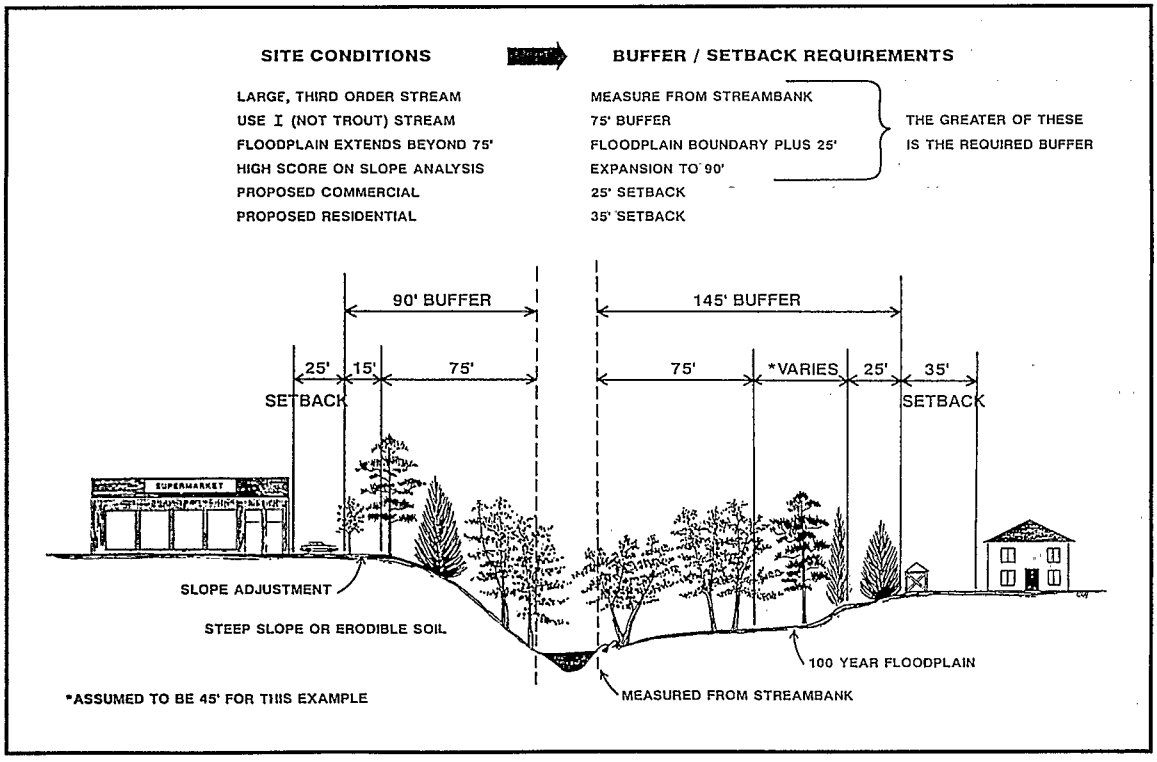
Baltimore County has 1,000 miles of streams that drain to three reservoirs and the Chesapeake Bay. To protect streams in new developments and to restore streams in existing communities, the county enacted legislation in 1991 requiring the reservation of stream system corridors. The legislation is called *Forest Buffers* and protects the stream, its associated wetlands, floodplains, and nearby erodible slopes. These forest buffers serve many purposes: filtering nutrients and toxics; reducing erosion and sedimentation; stabilizing streambanks; infiltrating storm water; maintaining base flow of streams; providing organic matter for the aquatic food chain and energy flow; cooling streams; providing wildlife habitat; providing scenic value and recreational opportunity; and minimizing water resource expenditures. Furthermore, the legislation also requires correction of existing stream pollution and degradation problems.

Four aspects of the stream protection legislation are distinctive or innovative. First, the concepts contained in this legislation were developed over a 2-year period by the Baltimore County Water Quality Steering Committee through a process of negotiation and consensus building. The steering committee consisted of representatives from the engineering, homebuilding, and environmental communities, and from county agencies. Second, the standards for forest buffers apply to all streams, including intermittent, unmapped streams. Baltimore County is probably unique in requiring protection of even its smallest streams. These smaller streams are essential to the ecological health of river systems, and forest buffers are most effective when applied to small streams. Third, the degree to which forest buffers are applied to a site is dependent on the environmental sensitivity of that site. Buffers are determined for each stream ranging from a minimum of 75 feet from the stream to as much as 300 feet from the edge of wetlands (see examples A and B on the next page). Finally, this legislation is integrated into Baltimore County's overall strategy for water quality management.



Example A



Example B

Controlling Nonpoint Source Pollution: A Cooperative Venture

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In November 1990, Congress, in response to water quality problems evidenced by beach closures, shellfish harvesting prohibitions, and the loss of biological productivity, determined that special protection for coastal waters was necessary and passed section 6217 of the Coastal Zone Act Reauthorization Amendments of 1990 (CZARA) (codified as 16 USC 1455b). Section 6217, applicable to the 29 states and territories with coastal zone management programs approved by the National Oceanic and Atmospheric Administration (NOAA) under the Coastal Zone Management Act (CZMA), requires states to submit Coastal Nonpoint Pollution Control Programs (coastal nonpoint programs) to the U.S. Environmental Protection Agency (EPA) and NOAA for approval. The goal of these programs is *to restore and protect coastal waters.*

The statute and legislative history make clear that a central purpose of section 6217 is to strengthen the links between federal and state coastal zone management and water quality programs in order to enhance state and local efforts to manage land use activities which degrade coastal waters and coastal habitats. The state coastal nonpoint programs are to build upon and integrate existing state and local authorities and expertise. They will employ initial *technology-based* management measures throughout the coastal management area, to be followed by a more stringent water quality-based approach, where necessary, to address remaining water quality problems. Section 6217 also requires some insurance, in the form of state enforceable policies and mechanisms, that nonpoint source controls are actually implemented.

Congress mandated extensive cooperation between NOAA and EPA, an extraordinary step that is actually working. The two agencies have, in a joint effort, provided guidance to the states on how to shape their programs to obtain federal approval. This guidance is entitled *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance* (January 1993). In addition, guidance was provided to the states on the management measures which will be used to address the major sources of nonpoint pollution in coastal waters. This guidance is entitled *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters* (January 1993). NOAA and EPA are also jointly responsible for approving the state programs.

Under CZARA, Congress required EPA, in consultation with other federal agencies, to develop guidance specifying management measures that reflect the *best available economically achievable* methods to control nonpoint pollution in coastal waters. The measures are designed to reflect the greatest degree of pollutant reduction achievable through the application of best available technology, siting criteria, operating methods or alternatives.

The management measures guidance includes a chapter for each of five major categories of nonpoint pollution:

- Agriculture.
- Forestry.
- Urban (including new development, septic tanks, roads, bridges and highways).
- Marinas and recreational boating.
- Hydromodification.

Also included is a chapter describing ways that wetlands and riparian areas can be used to prevent pollution from a variety of sources. Each chapter sets forth the management measures with which state programs must be in conformity. In addition, each chapter describes management practices that may be used to achieve the measure, activities and locations for which each measure may be suitable, and information on the cost and effectiveness of the measures and/or practices.

The management measures are described in terms of management systems rather than individual best management practices (BMPs). Many of these systems include actions that reduce the generation of pollutants—a pollution prevention approach—as well as actions to keep the pollutant from reaching surface or ground waters. Measures range from traditional activities such as erosion control to more comprehensive strategies such as watershed planning to help minimize urban runoff.

The program guidance describes what must be contained in each state program in order to be approved by EPA and NOAA. States will have.to address such issues as:

- Where the program will operate geographically.
- How the management measures and the associated practices should be selected and implemented.
- How the program should be coordinated with other state, local and federal programs.

As directed by section 6217(a), the geographic scope of each state coastal nonpoint program must be sufficient to ensure implementation of management measures to *restore and protect coastal waters*. State coastal zone management programs already have established geographic boundaries based on existing requirements and authorities needed to address the purposes of the CZMA. However, Congress recognized a potential need to revise those boundaries to better address the control of nonpoint sources of pollution. Accordingly, NOAA, in consultation with EPA, was directed to evaluate the existing state coastal boundaries and determine, on a state-by-state basis, how those boundaries compare to the management area necessary to meet the intent of CZARA.

As a starting point for its evaluation, NOAA selected coastal watersheds (as defined by the U.S. Geological Survey Cataloging Units) adjacent to the shore and extending inland along estuaries to encompass the head of tide. Based on nationally available data, NOAA has determined for each watershed whether significant indicators of coastal nonpoint source pollution occur within the existing coastal zone management boundary, between the coastal zone boundary and the coastal watershed, or inland of that watershed. In coastal watersheds where an area less than the coastal watershed captures most of the significant indicators of nonpoint source pollution, NOAA may recommend a lesser area for management. In the program guidance, this area is known as the *6217 management area*. A state may respond to this recommendation by either modifying the coastal zone boundary to implement NOAA's recommendation or by identifying other state authorities to implement the coastal nonpoint program throughout the 6217 management area.

NOAA will soon be making its boundary review recommendations. States will make initial decisions this year (1993) as to how they will respond to this recommendation and craft a rationale for any modifications. Once a state has identified gaps in the authorities to implement measures, it must develop a strategy for filling those gaps. States also need to evaluate how to make improvements where the authority appears adequate, but the implementation inadequate.

State coastal nonpoint programs must ensure the implementation of management measures *in conformity* with those specified in EPA's management measures guidance. In general, the presumption is that states will implement all management measures for the source categories (e.g., agriculture, urban) specified in the management measures guidance throughout the 6217 management area. However, states have the opportunity to exclude certain nonpoint source categories or subcategories in limited situations. States may exclude certain sources if they can demonstrate either:

- The source is neither present nor reasonably anticipated in an area or
- That sources do not, individually or cumulatively, present significant

adverse effects to living resources or human health.

It is anticipated that exclusions will need to be demonstrated on a watershed or localized basis.

States will also have some flexibility in that they may adopt either the management measures specified in the technical guidance or alternative measures to better meet local conditions, provided that the alternative measures are as effective as those found in the guidance in controlling coastal nonpoint pollution.

Coastal nonpoint programs must also provide information on how the state will be implementing the measure. States will need to ensure the implementation of management measures through the use of enforceable policies and mechanisms. Section 306(6)(a) of the CZMA defines enforceable policies as:

> . . . State policies which are legally binding through constitutional provisions, laws, regulations, land use plans, ordinances, or judicial or administrative decisions, by which a state exerts control over private and public land and water uses and natural resources in the coastal zone.

States can design a coastal nonpoint program that uses a variety of effective regulatory and nonregulatory approaches. Nonregulatory approaches must be backed by enforceable state authority which ensures that the management measures will be implemented. States will need to demonstrate that they have the authority to take enforcement actions where incentive or other programs do not result in implementation of the management measures, or where significant harm to coastal waters is found or threatened.

The selection and design of enforceable policies can be tailored to specific state or local circumstances. The approaches states choose should take into account the nature of the activity and existing institutions and authorities. States may also want to evaluate the costs and benefits of various approaches.

Enforceable policies may be established through state, regional, or local authorities. Where implementation occurs at the regional or local levels, the state must be able to exert or retain authority to ensure local implementation in accordance with the federally approved coastal nonpoint program.

Effective implementation of the enforceable policies and mechanisms will be aided by programs to educate the public about the importance of the management measures and to provide technical assistance to local governments and the affected interests. While public education and technical assistance programs alone may not be used to fulfill the requirement for enforceable policies and mechanisms, these programs can enhance the success of both regulatory and nonregulatory programs.

As an integral part of the coastal nonpoint program, the goals of the public involvement and education program should be defined by the state before it begins to develop its coastal nonpoint program. The public will need to be involved as early as possible in the development and implementation of the program, and the process should seek to promote and maintain the public's long-term commitment to the program. Each state must demonstrate that its coastal nonpoint program has undergone public review and comment prior to submittal to NOAA and EPA for approval.

States are now in the earliest stage of developing their coastal nonpoint programs. Most have begun analyzing existing authorities to implement the management measures, and have begun establishing mechanisms for coordinating program development work between the coastal and nonpoint programs. During this next year, states will be identifying land uses that cause or are likely to cause nonpoint source pollution affecting coastal waters. In addition, states will be identifying the real or potential nonpoint sources of pollution generated by those land uses.

The timeline for preparing the state coastal nonpoint programs and gaining federal approval is short. By statute, states have 30 months from the publication of EPA's management measures guidance under section 6217(g) to submit their programs to EPA and NOAA for approval, i.e. July 1995. States that fail to submit approvable programs will be subject to a loss of federal funds under both section 306 of the CZMA and section 319 of the CWA. These penalties begin with a 10 percent reduction in fiscal year 1996, and increase to a 30 percent reduction in fiscal year 1999, and each year thereafter.

Despite state concerns about the difficulties involved in developing this program, Congress is looking toward broader applications for this nonpoint pollution control

program. Efforts to reauthorize the Clean Water Act are expected this year, and there has been considerable interest in extending this program to encompass all states, not just coastal states and territories. Although it is too soon to demonstrate any success, the innovative nature of this program, its call for interagency cooperation, and its emphasis on building on existing state and local programs may prove an irresistible lure to a Congress deeply involved in reducing the federal deficit.

Improving Boston's Watershed Protection Program in Response to the Safe Drinking Water Act

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The Safe Drinking Water Act (SDWA), which governs the quality of water produced and delivered by cities throughout the Nation, was amended in 1986 to provide stronger safeguards against potential causes of waterborne diseases. This led EPA to establish a number of new drinking water quality regulations, including the Surface Water Treatment Rule (SWTR), which specifies criteria for deciding which systems must employ filtration. Generally, the SWTR requires systems to filter unless it can be shown that source water quality is extremely high and the watersheds are very well protected.

By requiring unfiltered systems to "establish and maintain an effective watershed control program" as one of the conditions for avoiding filtration, the SWTR has generated renewed interest in the value of watershed protection, especially in many cities that have depended on unfiltered supplies. In Boston, this interest has already yielded tangible benefits: better information has been developed on conditions and pollution threats within the watersheds; increased resources have been committed to strengthen the watershed protection program; and crucial legislation has been passed to establish 200-foot and 400-foot buffer zones along all tributaries.

Background on the Water System

More than 2 million persons in Boston and 45 neighboring communities are served by a regional system delivering water from three sources located 30 to 80 miles west of the city. Since 1985, two state agencies have shared responsibility for the quality and safety of the drinking water produced by this regional system. The Metropolitan District Commission (MDC) is responsible for managing and protecting the reservoirs and watersheds, while the Massachusetts Water Resources Authority (MWRA) is responsible for treating the water to meet regulatory standards and distributing it on a wholesale basis to the customer communities. The MWRA reimburses the MDC for the annual watershed program budget.

The three surface water sources have a combined watershed area of 400 square miles and are capable of safely yielding 300 million gallons of water per day. Twenty-six communities, most of which are not users of the metropolitan supply, have land within the watersheds.

Nearly half of the supply originates at the Quabbin Reservoir, which was constructed in the 1930s. Its large watershed area consists mostly of open forest and rural land, with 55 percent of the land area held in ownership by the MDC for supply protection purposes. The Wachusett Reservoir is the system's oldest active water source. Due to its proximity to urban centers, significant portions of the Wachusett watershed have become heavily developed and populated over the years. An intake on the Ware River also allows additional water to be diverted into the Quabbin Reservoir on a seasonal basis.

The Quabbin and Wachusett Reservoirs are operated in series, as all water moving east from Quabbin flows into the

Wachusett, and from there the blended water is transported eastward to the metropolitan area. Three small communities to the west also withdraw water directly from the Quabbin Reservoir through an aqueduct connection.

Regulatory Guidance

The published regulations of the Surface Water Treatment Rule provide only general guidance on what constitutes an "effective" watershed control program. The regulations state that, at a minimum, the program must:

1. Characterize the watershed hydrology and land ownership.
2. Identify watershed characteristics and activities which may have an adverse effect on source water quality.
3. Monitor the occurrence of such activities.

Furthermore, the water system must demonstrate that watershed lands are owned and protected in ways that control human activities that may have an adverse effect on the microbiological quality of the source water.

The Massachusetts Department of Environmental Protection (DEP) has provided additional technical guidance on the material and information required to receive consideration for a filtration exemption. In addition to identifying, assessing the risk of, and mapping a broad range of threats and activities, water systems are required to develop specific measures and implementation schedules to control all identified threats.

Planning for Compliance with the SWTR

With responsibilities for the water system split between a special-purpose authority and a state agency, compliance with the SWTR poses a unique institutional challenge. The agency responsible for meeting drinking water quality standards and treatment requirements, the MWRA, doesn't have regulatory authority within the watersheds, nor does it have direct control over the watershed protection program. Because the actions of the MDC could have a direct bearing on the required level of treatment to be provided by the MWRA, the MWRA commissioned a study in 1990, to be conducted jointly with the MDC, to evaluate the adequacy of existing watershed protection measures and to recommend improvements that would hopefully satisfy the filtration avoidance criterion.

At the time it was obvious that the MDC's watershed protection program was lacking. The watershed division of the MDC had been hit hard by several consecutive years of state budget cutbacks. Staffing levels had dwindled, key positions were unfilled, fewer dollars were available to carry out necessary programs, and pollution problems in the watersheds were mounting. By documenting these deficiencies, the 2-year study laid the groundwork for developing suitable watershed protection plans for each of the two reservoirs.

The actual conditions in the watersheds were evaluated in accordance with water resource protection guidelines put forth by the state DEP. Existing and potential pollution threats were identified and mapped, and rated in order of severity. The Quabbin and Ware watersheds were found to be in the best condition due to the relatively low level of development and the high proportion of land owned by the MDC. Recreation, road runoff, gravel mining, and animal populations were cited as the primary issues of concern in these areas.

The Wachusett watershed was found to be in a much more degraded condition due to years of unchecked urban growth, particularly in areas adjacent to rivers and streams flowing into the reservoir. The major problems identified were pollution from inadequate septic systems, contaminated land due to improper hazardous waste handling, leaking underground storage tanks, storm water runoff, risk of an accidental spill near the reservoir, overuse of herbicides and pesticides by private landowners, and bacterial loadings from gulls and geese on the water surface.

The study process culminated in the preparation of two Watershed Protection Plans: one for the Quabbin/Ware watersheds and one for the Wachusett Reservoir. The plans proposed specific actions needed to remediate existing pollution sources and prevent future threats. The plans also identified the resources needed by the MDC to successfully carry out the recommended actions. It was determined that the watershed division needed 220 full-time staff and an annual budget of $10 million, compared

with the present levels of 120 staff and an operating budget of around $6 million.

Improving the Watershed Protection Program

The Watershed Protection Plans, which were completed in 1991, are now being implemented by the MDC with assistance from the MWRA. Although the MDC's staffing and budget levels have not yet reached the recommended levels, progress is being made. The wave of cutbacks affecting the watershed division has not only been stemmed, there has been a distinct reorientation of the state's priorities relative to watershed protection. The MDC has been authorized to gradually fill additional positions and the Governor's budget proposal for the upcoming fiscal year includes $10 million for the watershed division.

Most importantly, actions are being taken to clear pollution sources from the watersheds and prevent future problems, in accordance with the central objectives established in the Watershed Protection Plans. These objectives are:

- Preservation of the most sensitive lands.
- Promotion of wise land use and development decisions.
- Appropriate control of recreation and public access.
- Resolution of problems associated with septic systems.
- Remediation of contaminated land sites.
- Reduction of risks from hazardous substances and wastes.
- Management of forests and wildlife in an ecological manner.
- Expansion of inspection, surveying, and monitoring efforts.

Preservation of sensitive lands will be achieved through increased land acquisition and new state legislation restricting land alteration along the banks of tributaries. The MDC's landholdings in the watersheds presently total around 82,000 acres, which is nearly one-third of the total land area. In the next 10 years the MDC will purchase an additional 20,000 acres, mostly in the Wachusett watershed. After 6 years of debate, a law was enacted in 1992 to prohibit any land-disturbing or polluting activities in areas within 200 feet of MDC water supply tributaries, and to restrict development and other activities between 200 and 400 feet from tributaries. The MDC is also authorized by this legislation to adopt necessary enforcement regulations.

Local land use decisions by the watershed communities will be influenced and assisted through new programs offering education and technical advice to local officials. While these suburban and rural towns retain strong home-rule powers and generally do not want their futures dictated by the needs of the metropolitan water system, there is much opportunity to promote environmentally sound development that can benefit the towns as well as the water sources. For instance, many of the pollution threats that are of concern to the MDC are also within the recharge areas of local wells.

One of the most serious problems facing the watersheds is the prevalence of inadequate and failing septic systems near the Wachusett Reservoir. A range of solutions is being explored, including constructing replacement sewers and providing financial assistance to affected homeowners to help pay for repairs. It is estimated that improvements costing more than $20 million may be necessary to correct this situation.

The MDC and the MWRA will step up pressure on responsible state agencies to clean up several sites contaminated by hazardous wastes. Prevention of future spills will be one of the MDC's highest priorities. Industrial facilities will be inspected more frequently to view equipment and procedures. All underground storage tanks will be inventoried and the information maintained on a regional data base. Roads and railways traversing the watersheds and reservoirs will be upgraded to minimize the risk of accidents and to contain spills should they occur.

Special efforts will aim to reduce the populations of birds, especially gulls, attracted to the reservoirs. High coliform bacteria levels in the source water are attributed to the bird population. Measures to be used include advanced harassment techniques and limiting nearby food sources, such as open landfills.

The maps generated during the study process will continually be updated using geographic information systems (GIS). These maps were instrumental in focusing attention to problem areas and are expected to be useful tools in tracking progress and new developments.

Protection Objectives Relative to Filtration

Due to the proven high-quality water at the Quabbin Reservoir, the relatively clean condition of the surrounding watershed, and the high level of land ownership maintained by the MDC, the state DEP has determined that the Quabbin Reservoir meets the SWTR criteria for continuing as an unfiltered source of supply. Successful implementation of the Quabbin/Ware Watershed Protection Plan will help keep this determination in effect for as long as possible. This will ensure that the western communities that rely on water taken directly from Quabbin will continue to be supplied with some of the best unfiltered water found anywhere in the Nation. In addition, all users of the system will benefit from the maintenance of high-quality water at the Quabbin source.

The Wachusett Reservoir, however, is in a more precarious condition. To date, its source water quality has not been shown to meet the criterion for filtration avoidance. The MDC and the MWRA are not certain that water quality can be upgraded and maintained through implementation of additional protection measures. Thus a dual-track planning approach is being pursued. One track is proceeding with facility designs under the assumption that a filtration plant will have to be in operation by 2001. The other track consists of aggressive watershed protection and water quality modeling to focus near-term efforts on the major pollution sources affecting reservoir water quality. This second track, which could lead to filtration avoidance, gives the MWRA valuable planning flexibility at a time when capital investment dollars are limited.

Conclusion

The development of the Watershed Protection Plans in response to the SWTR and the public debate on the buffer zone legislation worked together to raise awareness of the relationship between watersheds and drinking water quality. Now the value of watershed protection is more widely understood and appreciated throughout Massachusetts, and support for necessary action is more readily available. Regardless of the ongoing debate about the appropriateness of some of the treatment requirements mandated by the SDWA, there is no doubt that these regulations were key factors in the rejuvenation of Boston's watershed protection program.

The National Environmental Policy Act Process: A Tool for Watershed Analysis and Planning

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Implementation of the National Environmental Policy Act (NEPA) during the last two decades stands as one of the most successful elements of the federal government's commitment to environmental protection. Despite this success, NEPA holds even greater promise to improve the Nation's environment. Recognizing the mutual goals of NEPA and watershed planning, the NEPA process can facilitate watershed planning and management in a manner that will bring us closer to realizing the lofty goals articulated by Congress nearly 20 years ago when NEPA was passed into law. Using the NEPA environmental impact assessment process as a bridge, individual federal actions and responsibilities can be linked with comprehensive watershed planning.

Using the flexibility inherent in the NEPA process, innovative, integrated watershed planning that advances environmental risk reduction goals can be achieved with full public participation. The flexibility of NEPA, as well as its potential to achieve a number of objectives, is often overlooked. Broadly focused NEPA documents—those that go beyond site-specific, single-purpose proposals—can serve to integrate the variety of issues (e.g., floodplain encroachment, wetland losses, nonpoint source pollution, point source pollution, recreation, and soil erosion) that directly or indirectly relate to watershed management. In addition, through this flexibility, NEPA can provide:

- A forum for long-term watershed planning.
- A process for consideration of new policy directions and research.
- A framework for analysis and disclosure of site-specific environmental impacts of individual projects.
- An opportunity to assess cumulative effects and analyze management areas.

Federal, state, and local entities can use the NEPA process more effectively to provide the integrated resources analysis and planning required for comprehensive watershed initiatives. Federal actions triggering NEPA responsibility cover a wide range of actions and involve a variety of federal agencies. For example, Corps of Engineers' (COE) flood control and regulatory activities, Bureau of Reclamation's (BOR) water supply and management activities, Federal Energy Regulatory Commission's (FERC) hydropower licensing, and Federal Emergency Management Agency hazard mitigation actions all trigger NEPA analyses. Consequently, agencies and the public should view NEPA as an opportunity to initiate early and creatively integrated, multi-objective planning within the context of environmental impact assessment.

While watersheds may define the appropriate spatial boundaries for environmental, economic, and engineering plans, NEPA provides an appropriate framework upon which to organize analyses, planning, and management commitments for watersheds. Through the project and site-specific NEPA analyses typically performed by federal agencies, their expertise, funding, and commitments can be brokered into a broader watershed plan. Where the federal

project's purpose and need can be articulated in a broader sense, the NEPA process can serve to identify and address an expanded spectrum of issues and alternative solutions.

Use of the NEPA Process in the Context of Watershed Planning

The NEPA process allows agencies considerable flexibility to determine the appropriate scope of analysis, and therefore can often broaden that scope to a watershed level. Accordingly, it is most appropriate to prepare NEPA documents that look at watershed level impacts when: (1) the agency is evaluating a policy or program; (2) a series of similar or related actions are expected to occur within 10 or 20 years; or (3) several activities are occurring within a single watershed and need to be coordinated.

The basic components of the NEPA procedure—alternatives analysis; assessment of direct, indirect, and cumulative impacts; mitigation; and public involvement—are appropriate tools that can be utilized to realize:

- Integration of watershed planning and management within the broader context of water quality, natural resources protection and enhancement, and other social issues.
- Integration of cross-media, nonstructural, structural, and environmentally enhancing solutions to watershed issues.
- Multi-objective management of watershed features that address multiple problems (e.g., floodplain management, recreation, and wetlands protection).
- Assessment and establishment of a watershed's natural and beneficial uses and values.
- Integrated risk reduction.
- Integrated and coordinated federal, state, and local planning and resource management.

At a minimum, NEPA documents should be used to assess and establish a watershed's baseline conditions, natural and beneficial uses and values, and the potential for changes in those conditions and values. Thus, in its most traditional use, NEPA is an appropriate vehicle to promote early involvement in planning and risk reduction. However, NEPA can also provide for a much broader assessment of watershed planning issues.

Integrating All Levels of Government Through the NEPA Process

The NEPA process, particularly when broadly focused, facilitates coordinated implementation of multiple federal and state programs affecting a watershed and brings together appropriate federal, state, and local officials into a cooperative effort to address common goals. The NEPA process could, at best, be the framework or, at least, be one of the pillars supporting the watershed plan development process that integrates federal actions with other national, state, and/or local goals of water quality improvement, habitat protection, environmental risk reduction, recreation, and aesthetics.

The Council on Environmental Quality's (CEQ) regulations on the implementation of NEPA require that all reasonably foreseeable future actions be included in impact analysis so that decision-making is based on the total probable future condition of an area (CEQ, 1978). This requirement for a cumulative impact analysis links a site-specific proposal to broader watershed management issues. Through this analysis, local citizens and public officials are provided an opportunity to assess long-term trends, develop policies to address the desirability of such trends, assess their compatibility with other local goals, and develop means of coordinating local objectives.

Involvement of local jurisdictions in the NEPA process is crucial for development of meaningful evaluations and to determine those societal benefits that are desirable and those societal costs that are acceptable. For the NEPA process to work to its fullest potential, local jurisdictions should use the NEPA document to publicly indicate their capacity and willingness to implement measures to offset environmentally or socially unsatisfactory impacts.

Other Advantages of the NEPA Process

Other practical reasons exist to promote the use of the broadly focused

NEPA document. Watershed-scale NEPA documents can enhance public participation in a comprehensive planning process which can encourage "buying into" or committing to an overall program. Furthermore, such NEPA analyses can facilitate addressing site-specific actions through subsequent abbreviated impact analyses and permitting procedures, saving government agencies and developers time and money.

Federal, state, and local agencies may need encouragement to utilize NEPA to its fullest potential. Agencies may resist broadening the scope of analysis, taking a narrow approach that only addresses the specific federal action; the additional analyses may be seem as superfluous to the issue to be resolved. For a variety of reasons, federal regulatory agencies may resist programmatic NEPA analyses that do not directly relate to the immediate federal action. Although it is important to recognize that regulatory agencies are often burdened by a lack of staff resources, considerable time and effort savings needed for subsequent NEPA analyses can be realized through comprehensive planning. These attitudes, coupled with the lack of credit assigned to federal agencies for voluntarily undertaking programmatic efforts, limit comprehensive planning and regional issue resolution.

Another very practical reason for utilizing the NEPA process is the advantages gained from utilizing federal expertise. Furthermore, if a federal action triggers NEPA, and the federal agency chooses to facilitate watershed planning through the NEPA process, the federal government will be financially contributing, at least, to the impact analysis and development of alternatives solutions phases. If the federal government proceeds with its action, which presumably is consistent with the watershed plan, the federal government may be funding an aspect of the overall solution and may be contributing funds to monitoring efforts required to assess the success of the plan.

The U.S. Environmental Protection Agency's (EPA) Office of Federal Activities will be working to remove these barriers through active solicitation of federal agencies' support for a broadening of a single-purpose NEPA document or the development of programmatic documents to address comprehensive, integrated issue identification and resolution.

Federal Involvement in Watershed Planning and the NEPA "Trigger"

Numerous federal statutes, executive orders, and policies exist that can be interpreted as affecting federal participation in watershed planning. Clearly, there has been long-standing congressional support for federal assistance in watershed planning. Moreover, Executive Order 11988, *Floodplain Management*, encourages federal agencies to provide leadership and take action in aspects of watershed planning and management. When federal participation can be secured, the NEPA process may be "triggered" (i.e., there is a federal action that requires the preparation of a NEPA document) and watershed planning can be advanced. Agency involvement in these activities provides the necessary NEPA process trigger. A sampling of federal authorities follows:

- Section 1 of Public Law 87-639 (September 5, 1961) authorizes the Army (i.e., COE) and the U.S. Department of Agriculture (USDA) to make joint investigations and surveys of watershed areas and prepare joint reports on those investigations and surveys when authorized by Congress.
- Section 22 of Public Law 93-251 authorizes COE, in cooperation with states, to prepare comprehensive plans for "the development, utilization and conservation of the water and related resources of drainage basins."
- Public Law 566, the Watershed Protection and Flood Prevention Act (August 4, 1954), authorized USDA to cooperate with states and other public agencies in works for flood prevention and soil conservation.
- COE must consider in its planning process all practicable and relevant alternatives applicable to sound floodplain management, without prejudging one alternative as superior to any other (US Army, 1989).
- COE may participate in the planning of wastewater management facilities or systems. COE is authorized to provide advice or assistance to local or state agencies engaged in area-wide waste treatment planning at the request of such agency (US Army, 1989).

Therefore, state and local agencies and the public interested in utilizing the NEPA process in watershed planning may use these and other authorities to identify opportunities for involving federal agencies in watershed planning.

Examples of Use of the NEPA Process and Watershed Planning

There are numerous examples where NEPA has facilitated a watershed planning effort. Listed below are some more recent examples that show the range of activities incorporating the NEPA process and watershed planning:

- In COE's St. Paul District, all regulatory permit processing along the Red River of the North, in North Dakota, has been suspended until a programmatic impact analysis is conducted. Presumably this analysis will identify cumulative impacts and facilitate development of a regional plan for certain activities within the watershed.
- In BOR's Mid-Pacific Region, BOR is working with the State of California to develop a San Joaquin River Water Resources Initiative. This study will identify means of returning some of the environmental values lost within this watershed in part due to dam operations, water withdrawals, and agricultural practices.
- In the Pacific Northwest, a myriad of federal and state agencies are working together to address the decline of salmon fisheries.

In addition to these examples, EPA's Office of Federal Activities is currently involved in two issues that present unique opportunities for leveraging broad NEPA analyses to facilitate watershed planning. The first involves FERC relicensing and the second involves water supply contracts. By 1999, 335 FERC licenses expire for existing hydropower projects on 105 rivers in 24 states. These FERC licenses set environmental and operational conditions on hydropower projects for a 30- to 50-year period. Significant environmental problems (i.e., impacts to water quality, wetlands, fisheries, wildlife habitat, migratory birds, water-based recreation, and ecosystem integrity) have occurred from project construction and operation and will continue under status quo conditions. Similarly, over 200 long-term water supply contracts issued by BOR are expected to expire within the next 15 years in California. In both of these circumstances, we will be encouraging broad-scale NEPA analyses that seek to examine impacts from a watershed perspective.

Conclusion

The flexible nature of NEPA lends itself to use as a vehicle for accomplishing watershed analysis and planning with full public participation. A comprehensive NEPA document on a watershed scale assists in the problem identification and resolution process—moving participants from a general knowledge of what needs to be done, to identifying what *can* be done, and finally to obtaining desired results. Used to its fullest potential, a well-executed and documented NEPA process can provide a communication framework and action agenda long after the federal activity initiating the process has been approved. The comprehensive federal NEPA document, performed on a watershed scale, can result in federally-coordinated but locally autonomous actions with respect to other facets of the watershed plan. NEPA represents a valuable tool that federal, state, and local entities can utilize more effectively to realize significant benefits to both local watershed management and environmental protection.

EPA will be doing more to foster cooperation among the agencies to ensure better integration of watershed management within the broader context of water and natural resources protection and enhancement. The EPA's NEPA oversight responsibility stems from both NEPA and section 309 of the Clean Air Act, which requires that EPA review and comment on the environmental impact of any matter relating to the duties and responsibilities of the Administrator (including air quality, water quality, ecosystem protection, hazardous materials, and waste management). EPA uses its NEPA review responsibilities to encourage creative planning through the development of alternative analysis and mitigation measures to enhance environmental quality and/or reduce environmental risks.

EPA believes that it can utilize its NEPA review authorities to encourage

federal agencies to take a holistic review of the problems facing a given watershed. The agencies also should review their authorities and policies and promote, or at least participate in, watershed planning and management. However, EPA and other federal agencies cannot succeed in this effort alone. Strong local recognition of the value of such integration is necessary to encourage effective multi-objective floodplain management.

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The Greenway Chameleon

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How come we haven't done it? How come we haven't developed an interconnected system of watersheds, streams, greenways, and paths in this country? Partly because the combination of these practices is a new theory, but hey, our forefathers told us about the possibilities and then even built examples for us to follow. How come it's taken us so long? And now that we see and understand what to do, will we do it?

In 1865, Frederick Law Olmsted developed the greenway concept when he created the college grounds at Berkley. Later he perfected the idea in Boston's Emerald Necklace.

In 1929, Benton MacKaye described his design of the Appalachian Trail. Not just a hiking trail, it was also to be a giant dam and levee system for the entire Eastern Seaboard, the ultimate water and trail greenway.

In 1959, William Whyte coined the word *greenway* and wrote about the concept in *Securing Open Space for Urban America* (Whyte, 1959). In the chapter titled "Linkage" in his book *The Last Landscape*, he further advanced the concept of greenways (Whyte, 1968).

In 1977, Christopher Alexander with his partner authors wrote about the need for common and connected spaces for children and a network of bike paths in his book *A Pattern Language* (Alexander et al., 1977). He wrote, "Lay out common land, paths, gardens and bridges so that groups of at least 64 households are connected by a swath of land that does not cross traffic. Establish this land as the connected play space for the children in those households."

And then in 1987, *The Report of the President's Commission on Americans Outdoors* recommended greenways (President's Commission, 1987): "Communities would establish greenways, corridors of private and public recreation lands, and waters to provide people with access to open spaces close to where they live, and to link together the rural and urban spaces in the American landscape."

We now have books sitting on shelves for referencing, examples that we can study in person, an appreciation of multiobjective river corridors, wetlands policies, and new money for bicycle and pedestrian facilities. If it's assumed we're primed and ready, the next step is to decide how, this time, we're actually going to succeed at creating a multiobjective river corridor system with greenway components that interconnect all across the country.

Let's, just for the heck of it, look at another system in the United States, the interstate highway system. This system is now complete. How did that happen? After World War II, President Eisenhower tried to drive from the East Coast to the West Coast. He couldn't. He realized that, for national security reasons, this country needed to be connected so he could drive troops from one coast to the other. He decided to create the interstate highway system and he put Al Gore's father in charge of it. Money was appropriated, federal and state agencies were organized to oversee the work, and a goal was set.

For the interstate highway system, land was purchased, either through willing seller/willing buyer or by condemnation. The rationale was—it was for the public good. The group overseeing this endeavor was the federal government, a sort of big brother who could look out over all the landscape, acquire the necessary land, and join the segments together.

The land issues related to watersheds and greenways are more complex and in

today's climate taking land by condemnation is not viewed favorably, even by Congress. It's difficult to identify one overseer because even the Administration is loathe to control people's lives and their land. We must use different tacts.

First, we need to institutionalize the theories. Greenways and watersheds must become mainstream and common practice for homebuilders, federal agencies, local communities, and land conservationists. We need to make sure greenways fit everywhere, everyone knows about them, and all create them. Watersheds and greenways need to be household words like Kleenex and household practices like cleaning.

Second, citizens must be the leaders in developing this interconnected system of watersheds, greenways, and paths. They know their land and watersheds better than anyone and they are the most qualified, at the grass-roots level, to oversee the work.

Third, approval for this citizen lead movement must come from the Administration. They have the money and the regulatory process. Without their support, the cause will be just slogans on discarded placards.

1. How do we institutionalize watersheds and greenways?

For starters, we need to speak at each other's conferences and not just at our own. Greenway leaders need to speak at watershed conferences. Watershed speakers need to speak at homebuilders association conferences. Bikeway leaders need to speak at wetland conferences. We need to swap quality speakers as if we threw speaker references into a big pile, and every conference organizer had to blindly select a bunch.

We need to have rules, regulations, and planning documents that reflect wise watershed and greenway management. Rivers should resemble their natural state. Walkers should be allowed access the length of the river. Connections from stream to bike path should be coordinated.

Staff should all be trained in this watershed/greenway new thinking. There should be no hesitation on their part to "do the right thing." They should be reprogrammed often so they can automatically put into practice the most environmentally sensitive solution.

2. How do we motivate the citizens to be the leaders?

We help them organize. We give them all of our secrets. We applaud their work. We flatter them with praise. We go out on the road and cheerlead.

Each state should have an aggressive organization which encourages watershed/greenways and seeks to find the money to complete the work. This group should focus locally and statewide, but also have connections nationwide. The group should work closely with property owners. Unlike the interstate highway system, land should not be taken by condemnation.

Quality citizens should be cultivated. High caliber people attract high caliber people who do high caliber work. They are also respected in the halls of government and have connections to land and money. Rather than just saying, the grassroots should be mobilized, the adage should be—the grass roots will be mobilized with talented leaders in the midst.

3. How do we gain approval from the administration for institutionalizing watersheds and greenways and cultivating quality leaders?

Because they hold the money and oversee the regulatory process, they cannot be left out of this scenario.

We have to first get into the White House and see that the theories are communicated to them for acceptance. We need also to develop ways for them to participate that don't cost a lot of money and produce identifiable results.

Congress needs to be given well crafted suggestions for legislation. If there are federal roadblocks, those should be eliminated or lessened. Money should be made available to produce a tremendous return for the investment. A good case for the expenditure of these funds must be developed in light of the deficit.

We could do it. We could be the generation that realizes the dreams of our forefathers. We could be the ones to correct the environmental damage done by our immediate predecessors. We could make this wet greenway a chameleon that fits in deserts, forests, and city settings—changing the color and shape of America to more closely resemble our original country.

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National Marine Fisheries Service's Involvement in Watershed Management Through the Coastal Wetlands Planning, Protection, and Restoration Act of 1990

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The State of Louisiana contains 40 percent of the coastal wetlands in the coterminous United States, but is experiencing 80 percent of the Nation's coastal wetlands loss. The current loss rate is estimated to be about 25 square miles annually. For several years there have been numerous attempts to enact legislation to create a national program to support wetland restoration in Louisiana. These efforts resulted in passage of the Coastal Wetlands Planning, Protection, and Restoration Act of 1990 (CWPPRA, P.L. 101-646, November 29, 1990) which, coupled with state legislation creating the Louisiana Coastal Wetlands Trust Fund, provides the mechanism and funding to implement a program to restore degraded wetlands. CWPPRA is unique because it enables a comprehensive wetland conservation planning effort and provides significant funding to implement wetland restoration projects.

The passage of this act created an opportunity for all coastal states to develop and apply for funding to implement wetland conservation programs. It also specifically required the development of a long range plan for restoring, conserving, and enhancing wetlands in coastal Louisiana. To implement the program in Louisiana, CWPPRA formally established a Task Force composed of representatives of the Secretary of the Army (Corps of Engineers (COE)); Departments of Commerce (DOC), National Oceanic and Atmospheric Administration (NOAA), Interior (Fish and Wildlife Service, Minerals Management Service, U.S. Geological Survey), and Agriculture (Soil Conservation Service); the Administrator of the U.S. Environmental Protection Agency; and the Governor of Louisiana (represented by the Governor's Office and Department of Natural Resources).

As required by the act, the Task Force annually identifies and prepares a prioritized list of coastal wetland restoration projects in Louisiana to provide for the long-term conservation of such wetlands and dependent fish and wildlife populations. Priority ranking is based principally upon the cost-effectiveness of such projects in creating, restoring, protecting, or enhancing coastal wetlands, with due allowance for small-scale projects necessary to demonstrate the use of new techniques or materials for coastal wetlands restoration. Priority lists are submitted annually to Congress. To date, two project lists have been submitted to Congress and a third is being prepared.

To ensure the success of this program, Task Force agencies agreed that citizens and user groups of the coastal basins must become "stakeholders" in the restoration effort. Thus to assist in this planning effort,

the Task Force established the Citizens Participation Group as an advisory body. This group is composed of local government representatives and a variety of user groups, such as landowners, the petroleum industry, commercial and recreational fishing interests, and environmental organizations. In addition, during the first 2 years of planning, numerous public meetings were conducted by Task Force agencies to encourage public involvement and solicit wetland concerns and restoration recommendations within each of the nine coastal watersheds.

The Task Force will also prepare a Restoration Plan to identify wetland restoration projects. Like the Priority List, the Plan is to be focused on cost effectiveness in creating, restoring, protecting, or enhancing coastal wetlands. The Restoration Plan is to be completed within 3 years of passage of the act. The purpose of the plan is to develop a watershed and coastwide comprehensive approach to restore and prevent the loss of coastal wetlands in Louisiana. The Plan is to coordinate and integrate coastal wetland restoration projects to ensure the long-term conservation of Louisiana's coastal wetlands.

CWPPRA requires an evaluation of the Restoration Plan to be prepared by the Task Force and submitted to Congress not less than 3 years after the completion and every 3 years thereafter. The Task Force must also provide annual reports to Congress containing a scientific evaluation of the effectiveness of the coastal wetlands restoration projects carried out under the Plan.

National Marine Fisheries Service's Role in CWPPRA Activities

The NOAA Restoration Center (RC), located in the National Marine Fisheries Service (NMFS), has been designated as the national coordinator for NMFS involvement in CWPPRA activities. The RC, Southeast Regional Office (SERO), and Southeast Science Center (SEC) will provide wetlands restoration expertise. CWPPRA goals should fully complement NMFS's priorities and programs (NMFS Strategic Plan, 1991).

As a member of the CWPPRA Task Force, NMFS assists in the development of the long range watershed conservation plans to protect, enhance, and restore Louisiana's coastal wetlands. Fulfilling this objective requires the determination of problem areas and restoration opportunities, reviews of wetland site selection and potential restoration, conservation or enhancement options, and the development of monitoring criteria. During 1992, a comprehensive monitoring plan was completed as a guide to developing scientific evaluations of each funded restoration project. As provided in the act, economic analysis is performed for determining the benefits and costs of various restoration or conservation measures.

For NMFS, this objective provides an opportunity to help develop the long range plan to protect Louisiana's wetlands consistent with its own priorities in habitat protection. It also provides an opportunity for NMFS to work more closely with its fishery/wetland constituents and build upon existing relationships.

Project Development

As a member of the CWPPRA Task Force, DOC/NOAA shares responsibility for identifying coastal sites to be considered for possible restoration or protection. Generally, the following steps are involved:

- Identifying restoration opportunities.
- Conducting field investigations to gather preliminary information on potential restoration sites.
- Developing project proposals offering possible restoration alternatives and related costs.
- Conducting wetland value assessments and economic analyses to determine the ecological value of the wetlands and project cost effectiveness.

If selected for funding by the Task Force, the following actions are required: detailed site investigations, landowner agreements, permit applications for the restoration, permit review and comment (e.g., NEPA and Clean Water Act compliance), advanced planning and engineering of the restoration project, actual restoration construction activities, long-term maintenance, and restoration site monitoring.

In fiscal year 1992, NMFS investigated 17 sites in Louisiana for possible restoration projects. Field investigations of wetland sites have required contractual assistance. The RC has assumed the role of contract manager for field investigations to be performed under the day-to-day direction of SERO. This provided an opportunity for the RC to develop contracting and manage-

ment expertise, while the SERO focused on planning and permitting activities.

Advanced planning and restoration engineering require engineering and wetlands construction expertise. Such resources may be provided by other Task Force members (e.g., COE). However, engineering and construction oversight will likely require the use of private contractors to support the RC and SERO. The RC has developed the necessary contractual and agency coordination to provide engineering support necessary to facilitate successful restoration efforts. Involvement in this activity provides NMFS an increased expertise in restoration project planning and implementation. Contractual support, when properly overseen by the SERO and the RC, will increase NOAA's wetlands protection and restoration capabilities.

Monitoring within the development of a long range plan and in actual restoration cases is critical to evaluating the success of the program. A standardized monitoring protocol based on project types (e.g., sediment diversion or hydrologic restoration) has been developed by a Task Force working group. This effort provided an opportunity for the RC and SEC to emphasize the need for comprehensive monitoring of all restoration cases.

Priority List Projects

In 1991 and 1992, NMFS, as lead agency, was awarded funding for five projects. Three were hydrologic restoration projects at Point au Fer, LaCache, and Fourchon. Two were projects to enhance sediment delivery and distribution to the lower Atchafalaya River delta (Louisiana Coastal Wetlands Conservation and Restoration Task Force, 1991, 1992). The projects are within three coastal Louisiana watersheds. Total area benefited by the five projects, once they are fully implemented, is approximately 14,000 acres. For informational purposes, a synopsis of two of the projects follows.

Lower Bayou LaCache Hydrologic Restoration

Site Description

Since 1932, at least 12 mineral access canals have been dredged into or across the project area from Bayou Terrebonne (to the east) and Bayou Petit Caillou (to the west). This has resulted in saltwater intrusion into the low-salinity, interior marshes of the project site. Additionally, the banks of Bush Canal at the north border of the area have largely disappeared resulting in the conversion of about 70 percent of the northern third of the project area to open water. Tidal exchange rate appears to have changed from north/south flow at restricted velocities to a rapid flow-through pattern throughout most of the area. Tidal scouring appears to have contributed to significant marsh erosion.

Proposed Restoration Activities

The intent of this project is to restore natural north-south tidal exchanges and salinity gradients and to reduce flow through the dredged canals by constructing shell-reinforced plugs at the mouths of each of nine canals along Bayou Petit Caillou and six canal plugs along Bayou Terrebonne. This should reduce saltwater intrusion and tidal scouring occurring through the series of access canals. The project will enhance habitat conditions in 4,500 acres of wetlands and slow the loss of an estimated 256 acres over the next 20 years.

Status

The completed cooperative agreement was approved by DOC in November 1992. Implementation of Phase I of the project will begin following State signature of the cooperative agreement.

Projected Cost

The cost of this project is estimated to be $1.1 million, with the federal contribution being approximately $825,000.

Big Island

Site Description

Big Island, located near the mouth of the Atchafalaya River, was created with dredge spoil from the Atchafalaya River navigational channel. Although no spoil has been deposited on the island since the mid-1980s, the location and size of the island prevent the river delta from prograding and creating new wetlands along the western side of the river's main channel. Due to dredging for navigation and other alterations, this segment of the Atchafalaya River delta complex has ceased to grow despite enor-

mous sediment inputs from the river. Combined with the erosional problems in the area, an estimated 2034 acres could be lost through natural deterioration over 20 years.

Proposed Restoration Activities

A channel with a bottom width of 500 feet and a depth of 6 feet is to be dredged at a 45 degree angle through Big Island. This will allow water and sediment to flow around a series of delta lobes, to be created with the material from dredging the channel, and thus allow the delta to prograde. Dredged material deposition is expected to create 300 acres of wetlands during construction and 1,200 acres are expected to accrete naturally over the life of the project.

Projected Cost

The total cost for this project is approximately $4,100,000 with the federal portion being $3,075,000.

Coastal Restoration Plan

The priority projects approved by the Task Force and to be undertaken by NOAA and other Federal agencies represent readily implementable actions to address individual wetland loss problems or enhancement opportunities. These projects essentially represent stopgap measures to be implemented while comprehensive watershed plans are being completed. The watershed restoration plans will provide a framework for wetland restoration within each basin, will identify projects critical to and supportive of successful watershed restoration, and will be coordinated among the different coastal basins to ensure a holistic approach.

Restoration plan development has involved NOAA and other Task Force agencies, the Citizens Participation Group, the academic community, and the public at large. This effort was initiated through a series of public meetings intended to provide information about CWPPRA and solicit comments, concerns, and recommendations pursuant to requirements of the act. Subsequently, open forum workshops were held during which pertinent information on each watershed was presented and discussed. Each workshop resulted in a written summary of environmental conditions; a concise problem statement; and conceptual, alternative restoration plans for each basin.

Utilizing information gathered and developed as a result of the public meetings and workshop deliberations, Task Force subcommittees are preparing watershed restoration plans for each coastal basin. These plans will identify problems and opportunities, specify critical and supporting restoration projects, and provide information to allow a ranking of projects based on cost-effectiveness and other criteria. Combined in a comprehensive restoration plan, the watershed plans will be subject to agency and public review and comment prior to submission to Congress. Once submitted, the restoration plan will become the basis for selecting future projects for funding and implementation under the CWPPRA.

Summary

CWPPRA provides an opportunity for DOC, NOAA, and NMFS to participate in a federally sponsored program with COE and other parties to restore, conserve, and enhance coastal wetlands in Louisiana. NMFS currently is planning the restoration of approximately 14,000 acres in the coastal zone of Louisiana and actively participating in the development of a statewide comprehensive restoration plan. Through NOAA's involvement a better understanding of and emphasis upon wetland restoration, protection, and conservation efforts in the Louisiana coastal zone can be applied to other restoration opportunities throughout the United States.

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New Federal Directions

Many federal, state, and local agencies are taking an increasingly integrated approach to watershed management in an effort to focus on whole ecosystems, tailor their actions to local needs, and make the best choices using limited resources. Some of the federal agencies involved in setting new directions for watershed management (the U.S. Environmental Protection Agency, the Forest Service, the Army Corps of Engineers, the Bureau of Reclamation, the Soil Conservation Service, and the Fish and Wildlife Service) participated in a panel discussion that reviewed some of the efforts underway. Other agencies (conference sponsors) provided brief written summaries describing how they are developing and implementing new approaches to watershed management within their agencies and in partnership with others. These summaries are included along with the papers from the panelists in this section of the proceedings.

U.S. Environmental Protection Agency

The U.S. Environmental Protection Agency (EPA) recognizes the need for comprehensive, holistic approaches to address today's challenges—significant water pollution from nonpoint and nontraditional sources, maintaining safe drinking water supplies, and habitat restoration and protection. EPA encourages and advances watershed efforts at all levels of government and is actively involved in many watershed partnerships.

EPA has years of experience in partnership programs such as the National Estuary Program, the Clean Lakes Program, the Rural Clean Water Program, the Great Lakes Water Quality Initiative, the Gulf of Mexico Program, and the Chesapeake Bay Program. These programs illustrate that successful watershed protection efforts have three key elements: broad stakeholder involvement, risk-based problem identification, and integrated actions tailored to needs.

Through the Watershed Protection Approach, EPA has recently intensified efforts to support watershed management. EPA programs may provide regulatory, technical, and financial assistance in such areas as nonpoint source pollution abatement, water quality assessment and monitoring, water quality criteria and standards, wetlands protection, effluent discharge permits, wellhead protection, underground injection control, comprehensive state ground water protection, and drinking water protection.

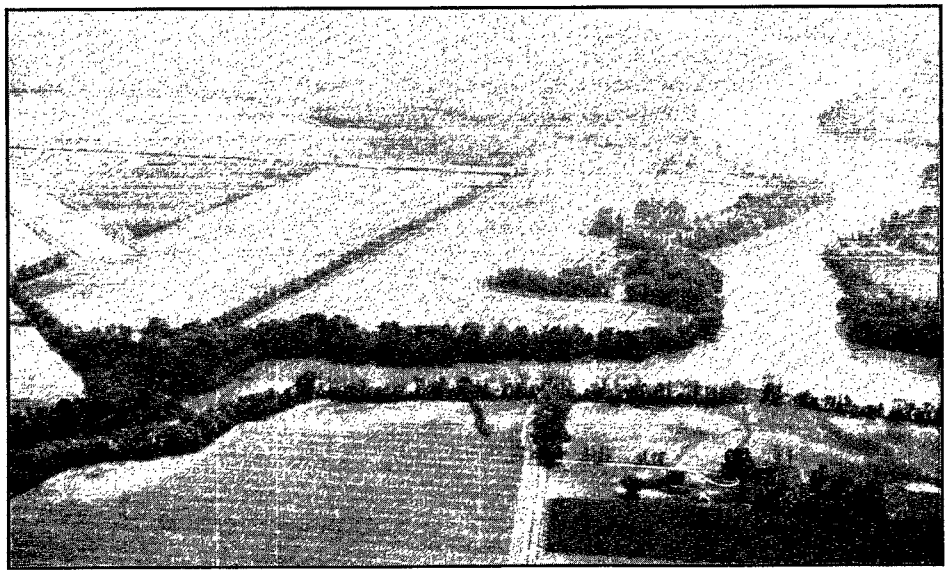

Photo courtesy of John Hoffheimer

USDA Forest Service

During the spring of 1992, the USDA Forest Service unveiled a new management philosophy and direction—"ecosystem management"—to achieve the multiple-use goals of the National Forests and Grasslands. This philosophy will also be actively promoted in cooperative relationships with state and private forestry organizations and in forest research activities. Ecosystem management is the skillful, integrated use of ecological knowledge at a variety of scales to produce desired resource values, products, services, and conditions that will sustain the ecosystem's diversity and productivity. Like the ecosystems themselves, management on an ecosystem basis is evolving as new knowledge and experience come to light.

This commitment and shift in philosophy come at a time when the demand by a very diverse public for a wide range of goods, services, and values is at an all-time high. This new direction initiates the Forest Service's holistic watershed management approach, which exhibits a greater sensitivity to all environmental values in our nation's forests.

U.S. Army Corps of Engineers

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Since the early 1970s, the emphasis of the U.S. Army Corps of Engineers (Corps) has shifted from development to the improved operation of existing projects, with special concern for impacts on the environment. Today, Corps funds budgeted for the operation and maintenance of existing projects exceed those budgeted for new construction.

As a result of legislative and policy changes, environmental restoration is now a "high-priority" mission in the Corps's budgeting process along with the more traditional missions of navigation and flood control. The Corps can now participate in the modification of existing projects for fish and wildlife habitat restoration.

As has occurred historically, these changes in the Corps's water resources development program reflect changing national preferences and desires. The Corps's study process begins with an authorization by Congress for a specific project or program investigation, most often initiated by a request from local interests. The study and implementation process then includes a partnership with nonfederal interests and input from the public. Following are examples to illustrate some of the new directions the Corps is taking in watershed management.

Kissimmee River Restoration Study

Authorized by section 116 of the Water Resources Development Act of 1990, the Kissimmee River Restoration Study is one of the largest environmental restoration studies in which the Corps has participated to date. The objective of the restoration plan is to restore the Kissimmee River ecosystem in central Florida to more natural conditions. Although restoration plans are being developed for both the Upper and Lower Basin areas, this discussion is of the Lower Basin plans, which are more complete. In fact, funds have been included in fiscal year 1993 to begin implementation of the Lower Basin phase of the project.

Prior to channelization, the Kissimmee River meandered approximately 103 miles across a 56-mile and 1- to 2-mile-wide floodplain. The river meandered very slowly, with velocities averaging less than 2 feet per second. Overbank flows appeared periodically. In 1961, in response to a request from the State of Florida, the Corps began a far reaching flood control program, including channelization, that brought major ecological changes to the river and its floodplain.

With channelization, about 21,000 of the original 35,000 acres of floodplain wetlands in the Lower Basin were drained, covered with dredged material during canal construction, or converted to channels. Most of the broadleaf marsh, wetland shrub, and wet prairie communities that once dominated the area are now converted to pasture. Maintenance of stable water levels has also reduced plant communities within the remaining inundated portions of each canal pool.

River channelization, drainage, and other modifications to wetland plant communities have had wide-ranging ecological consequences. These include loss of fish and wildlife habitat, and the virtual destruction of a complex food network that the floodplain wetlands once supported. Since channelization and the loss of wetland prairie habitat, wintering waterfowl and wading bird populations have decreased significantly.

*The views expressed are those of the author and not of the Department of the Army or the U.S. Army Corps of Engineers.

Components of the recommended plan include backfilling about 29 miles of existing channels; excavating about 11.6 miles of new river channel; and extensively modifying and removing weirs, levees, and other channel features. Plan outputs will include restoration of approximately 55 miles of river and 29,000 acres of wetlands, restoration of fish and wildlife habitat, and improved water quality. Wetlands acreage, habitat values, and wading bird populations are projected to be restored to more than 80 percent of historical conditions, and waterfowl populations to approximately 100 percent.

As with the Corps's traditional missions, partnerships with nonfederal sponsors are integral to the success of environmental restoration programs. In the case of the Kissimmee, the South Florida Water Management District is the nonfederal sponsor and will share equally with the Corps in the cost of project features, estimated at $280 million, based on 1991 price levels. Nonfederal interests will also provide locally preferred features at an estimated cost of $147 million and annual operation and maintenance. Although the South Florida Water Management District is the official nonfederal sponsor, it is not the only other partner in the process. Numerous other federal, state, and local agencies, organizations, institutions, and interested individuals participated throughout the problem identification, planning, and evaluation efforts.

Section 1135 Program

For smaller projects, section 1135 of the Water Resources Development Act of 1986, as amended, authorizes the modification of existing Corps projects to provide for fish and wildlife habitat restoration. This can occur if the Corps project contributed to the degradation or if the restoration can most effectively be accomplished through the modification of an existing Corps project.

Under the section 1135 program, total project costs cannot exceed $5 million and cost sharing with nonfederal partners is required. For fish and wildlife habitat restoration, the federal share is typically 75 percent of the construction costs. The nonfederal share is 25 percent for construction, and they also provide operation and maintenance. The section 1135 program received initial funding in fiscal year 1991. To date, 44 project modification studies have been initiated.

During 1992, the first 1135 project was completed—the closure of New Cut, in Savannah Harbor, Georgia. This project will restore approximately 4,000 acres of freshwater marsh and will provide habitat for a naturally recurring striped bass population in the back river system. The Board of Commissioners of Chatham County is the local sponsor with funds provided by the Georgia Port Authority.

An example of a section 1135 project currently in the feasibility stage of study is the Galilee Bird Sanctuary Salt Marsh Restoration. The project is also being considered as a Demonstration Project in the Coastal America Initiative Program. The Sanctuary contains about 130 acres of salt marsh and former salt marsh, and it is located in Narragansett, Rhode Island. It is listed in the Atlantic Coast Joint Venture of the North American Waterfowl Management Plan, attesting to its importance to black ducks and other waterfowl.

Over the years, filling with dredge material and constrictions in tidal flow, partially resulting from road construction, have resulted in significant losses of saltwater marsh habitat. Approximately 75 percent of the former salt marsh is now dominated by common reed and other upland vegetation. Soil and water salinity levels need to be increased, by reintroducing tidal flows, if this vegetation is to be eliminated and the salt marsh restored.

The restoration plan under study includes installing one or more culverts through an existing road; constructing a system of channels to convey tidal water throughout the marsh system; reconfiguring or removing existing dredged material; and constructing additional features, such as tide gates or dikes, a wildlife observation platform, and wildlife habitat features. It would restore approximately 80 acres of salt marsh, increase the tidal range to the 50 acres of existing salt marsh, and improve waterfowl habitat.

The Rhode Island Division of Fish and Wildlife is the local sponsor. Other participants include the U.S. Fish and Wildlife Service; the Rhode Island Department of Transportation; the U.S. Environmental Protection Agency; the University of Rhode Island, Department of Natural Resources Science; Ducks Unlimited; and the National Fish and Wildlife Foundation.

Upper Mississippi River System Environmental Management Program

Authorized by section 1103 of the Water Resources Development Act of 1986, the Upper Mississippi River Environmental Management Plan, or EMP, is another example of the Corps's commitment to the protection and restoration of the Nation's environmental resources. The EMP is a long-term program designed to protect and balance the resources of the Upper Mississippi and to guide future river management. Congress placed federal management responsibility for the program with the Corps. In implementing the program, the Corps actively coordinates with the U.S. Department of the Interior; the Upper Mississippi River Basin Association; and the five states of Illinois, Iowa, Minnesota, Missouri, and Wisconsin. The public also plays a central role in the EMP.

The Environmental Management Program consists of five components: habitat rehabilitation projects, long-term resource monitoring, recreation projects, a study of the economic impacts of recreation, and navigation monitoring. Approximately 97 percent of the EMP's authorized funding is targeted for habitat projects and for long-term resource monitoring. In the past, lack of information on the Upper Mississippi River has made it difficult for federal and state agencies to manage the river for competing resources. The long-term resource monitoring component of the EMP is addressing this problem through data collection and analysis. Sedimentation is widely considered to be the most severe environmental problem on the river. Agricultural activities and residential and highway construction have contributed to excessive erosion and sedimentation. Commercial navigation and recreational boating also contribute to these problems. The habitat projects are addressing these types of adverse changes by restoring and protecting high-value fish and wildlife habitat areas.

To date, 93 potential habitat projects have been identified. Of these, 18 have been completed or have construction underway and 36 are in various stages of the design and review process. Through fiscal year 1992, approximately $52 million had been allocated for habitat projects.

An example of a completed EMP habitat project is the Island 42 Backwater Restoration and Waterfowl Enhancement project in Minnesota. Installation of a culvert and channel provides water flows to a semi-isolated backwater area to alleviate low dissolved oxygen problems. In addition, the backwater area was deepened by dredging to improve 95 acres of fish habitat. It is estimated that fish production in the improved areas will increase by 50 to 75 pounds per acre. Because the restoration was on lands of the National Wildlife and Fish Refuge, 100 percent of the implementation costs were federally funded, with the U.S. Fish and Wildlife Service assuming the operation and maintenance responsibilities.

Another completed EMP project is the Blackhawk Park Restoration Project in Wisconsin. Here, approximately 7,000 linear feet of channels were excavated to improve dissolved oxygen levels for fish habitat. The improvements should yield annual production increases of approximately 20,000 fish from these backwaters. This project was cost-shared with the Wisconsin Department of Natural Resources, on a 75 percent federal and 25 percent nonfederal basis.

Other Activities

As illustrated in the above examples, effective watershed management requires a partnership effort. The Corps participates in various partnership programs with other federal and state agencies to promote beneficial resource management.

Previously mentioned was the Coastal America Initiative, a coordinated, multiagency effort addressing environmental problems along the Nation's shoreline. Coastal America demonstration projects, such as the Galilee Bird Sanctuary Restoration Project, will serve as models for effective management of coastal resources.

The North American Waterfowl Management Plan is an international plan designed to reverse the downward trend in North America's waterfowl populations by protecting and improving waterfowl habitats. Department of the Army support for the Plan is set forth in an agreement signed with the Department of the Interior in 1989. Many Corps projects contribute directly, or indirectly, to the habitat base for the Nation's waterfowl. Corps participation in this partnership contributes to achieving the Plan's long-term goals.

The Corps also cooperates with the National Marine Fisheries Service in The Marine Fish Habitat Restoration and Creation Program. This is a national program for fish and shellfish habitat restoration and creation. The goal of the partnership is to increase marine fish and shellfish productivity and to advance habitat restoration technology in conjunction with the Corps's civil works program.

The National Estuary Program is an interagency program that is developing plans for estuaries designated as nationally significant by the U.S. Environmental Protection Agency. The program helps coordinate federal, state, local, and private action to protect and restore estuaries and their surrounding wetlands. The Corps participates in the management and technical advisory committees of the estuaries being studied.

The Corps also conducts research and special studies in support of water resource management responsibilities. For example, the new administration has made equal consideration of environmental and economic factors, through sustainable development, a central theme in all areas of national policy—from foreign affairs to health care and job creation. An integral concept in this theme is the use of market-based approaches to resource management and environmental problems. While these concepts are new to many, the Corps is no stranger to market-based concepts in its water resource planning program. The Corps has a long tradition of cost-benefit analysis. The cost sharing reforms of the Water Resources Development Act of 1986 provide a true test of partners' willingness to support improvements not only for traditional development, but also for environmental restoration. Current efforts in developing the policies and technology for wetlands mitigation banking, for evaluation of environmental investments, for incremental cost analysis, and for risk and uncertainty analysis are examples of the Corps's continuing commitment to the exploration and, where appropriate, application of market-based concepts to the Nation's resource problems and opportunities.

U.S. Bureau of Reclamation

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This opportunity to reflect with you on the new and changing directions of the Bureau of Reclamation is appreciated and welcomed. To do so, we need to discuss two particular ideas. The first is the Strategic Plan of the Bureau of Reclamation for the next 10 years. The second idea we should talk about is Public Law 102-575, signed into effect in November 1992. This bill is the first omnibus bill given to Reclamation for many years. It certainly has many titles that will help shape the future direction of the Bureau of Reclamation. We can and should discuss this area, but first let me set the stage with some background information. To do this, I have referenced (with his permission to do so) several comments made by Donald Glaser, presently the Acting Assistant Secretary for Water and Science in the Department of the Interior, at the Upper Missouri Water Users Association meeting held in the winter of 1992.

Back in 1987, top management at the Bureau of Reclamation took a hard look at the program direction of the agency. A thorough assessment was made of the traditional development role and a need to refocus the emphasis of the agency's mission in the future to that of management of water resources. Over the past several years, under Dennis Underwood's leadership, we have been trying to focus this vision for the agency throughout the West.

Let me read the Bureau of Reclamation's mission statement: *To manage, develop, and protect water and related resources in an economically and environmentally sound manner in the interest of the American public.*

This mission statement is predicated upon a recognition that future water resource management in the West must be based upon wise and balanced multipurpose use of our limited western water supply. Water demands are growing in the West, and the supply of water is finite. The drought conditions we have seen in the last 6 years demonstrate clearly how narrow the margin of reserve between water development and water demand is throughout the West.

One thing we have found is that every action or objective seems to make sense if taken one at a time, and yet taken together they may make no sense. For that, we need a more comprehensive focus to test individual actions against.

We are working at instilling in staff throughout the Bureau of Reclamation a passion for public service—that is, a desire by every Reclamation employee to make each individual decision to achieve a common focus to our mission and consider the larger public interest.

As a part of the effort to do this, we have taken the 1987 Assessment of our program and expanded it forward into a Strategic Plan. This Strategic Plan was just finalized and released in June 1992. It is intended to be the broad framework to carry us into the future. The cornerstone of this plan is founded on working and investing together to build better coalitions through partnerships.

The plan is divided into five major categories, which include:

1. Managing and developing resources.
2. Protecting the environment.
3. Safeguarding the public's investment.
4. Building partnerships.
5. Fostering quality management.

These categories have 25 separate program elements that address specific programs and objectives. We are presently working on implementation plans for these 25 elements.

Illustrative examples of these program elements would include:

- Water and power operations.
- Water conservation.
- Drought management.
- Land resources.
- Recreation.
- Fish and wildlife resources.
- Water quality.
- Instream flows.
- Wetlands and riparian habitat.
- Facilities maintenance.
- Dam safety.
- Recovering the federal investment.
- Assisting other nations.
- Organizational excellence.

These in-depth plans state specific goals and time frames for achieving goals over the next 10 years. Specific implementation plans are reasonably well defined at the present time for 10 of the 25 elements, and these plans are under review in a rather open public forum. The other 15 implementation plans will be completed in the next few months and will receive a similar review process. We welcome comments on any of these plans from you or other interested parties.

We have also completed an Accomplishments Report that shows you, our customers, just how we have served you from 1989 to 1991. And, we will be issuing a 1992 Accomplishments Report in the future. We believe that it is important to let you know what we are doing to prepare for the future, and the new directions the agency is taking.

This preparation for a refocused future is going to be very important given the general sentiment in this country toward change. That is clearly evident in the recent elections. I will discuss issues relative to Reclamation projects that are very likely to develop in the upcoming months.

Traditional water development is very unlikely in the future. Rather, conservation, water transfers, water reclamation and reuse, and multiple uses of water will be the emphasis. Irrigation drainage and agricultural runoff as they relate to water quality are issues we will need to address.

As it relates to Reclamation projects, water pricing will be a major issue. Current agency water pricing practices are generally viewed as poor business practices that encourage misuse of limited water resources.

Double subsidy issues will become a focus as they relate to Reclamation projects. It is our belief that this will be dealt with from the Reclamation water pricing perspective as opposed to the price support side.

Perpetual rights to water from Reclamation projects will also come under review. This is clear, given the recent amendment passed in Title XXXIV of Public Law 102-575 limiting the contract terms of the Central Valley Project in California to 25 years upon renewal.

Most important is the fact that Reclamation projects will be managed to recognize the interests of a much broader constituency. They will become much more multipurpose in the future. This will result in new partnerships and coalitions for Reclamation that are different from those in the past.

Throughout the West, conflicts are developing between historic coalitions. These include agriculture and urban water users, flatwater and white-water recreationists, recreational fishing and white-water recreationists, and advocates for exotic fish like the rainbow trout and for native fish (endangered species) like the chub or sucker. These apparent conflicts can cause discord as well as windows of opportunity. In our future directions we hope to seize upon these as opportunities for better water management.

As we look to the future direction of the Bureau of Reclamation, special attention has to be given to Public Law 102-575, entitled the *Reclamation Projects Authorization and Adjustment Act of 1992*, signed by former President Bush on October 30, 1992. The law has 40 titles and is a very significant piece of legislation. This bill gives insight into the congressional perspective for new direction for the Bureau of Reclamation on several western water issues.

For example, Title II, the Central Utah Project Completion Act, generally provides for completion of the Central Utah Project by increasing the amount of funds to be appropriated for construction of authorized project features. However, one specific provision of the title that is of interest provides for 10 percent of full cost of water charged for the production of any surplus crop. This is similar to a requirement of the Garrison Reformulation Act of 1986. In the case of Garrison, this amounts to a surcharge of $65.00 per acre-foot.

Title XVI, Reclamation Wastewater and Groundwater Studies, gives the Interior Secretary broad authority to investigate and identify opportunities for reclamation and reuse of municipal, industrial, domestic, and

agricultural wastewater and naturally impaired ground and surface water Westside. It also gives demonstration and construction authority.

Title XVII, the Grand Canyon Protection Act, places legislative operating conditions on the Bureau of Reclamation's Glen Canyon Dam and Powerplant to benefit the downstream cultural, environmental, and ecological resources.

Under Title XXX, the Western Water Policy Review, the President is directed to undertake a comprehensive review of federal activities in the 19 western states that directly or indirectly affect the allocation and use of water resources, whether surface or ground water. An Advisory Commission has been appointed to assist the President in this effort.

Title XXXIV, the Central Valley Project Improvement Act for California, is an extensive title authorized to provide for the protection, restoration, and enhancement of fish, wildlife, and associated habitats in the Central Valley and Trinity River basins of California. It is intended to achieve a reasonable balance among competing demands for the use of Central Valley Project water, including requirements of fish and wildlife, agricultural, municipal and industrial and power contractors. To this end, the act provides for the following:

1. Limits agricultural contract renewals to 25 years.
2. Encourages water transfers from agricultural to urban uses by changing authorized uses of water and the project service area.
3. Directs that all renewals and future contracts must provide for metering water deliveries, both urban and agricultural.

The bill also provides for tiered pricing. The first 80 percent of water contracted for will remain under the current cost of service pricing structure, while the next 10 percent will be priced halfway between the current pricing structure and full cost. Finally, the last 10 percent contracted for will be at full cost. Water charges will be based upon actual water delivered.

In addition, the title stipulates that all increased revenues go to a fund for fish and wildlife restoration. Finally, the title sets aside 800,000 acre-feet of project water for the purpose of fish and wildlife restoration.

What does the Bureau of Reclamation understand the impact of Public Law 102-575 to be on our agency?

1. If we fail to resolve environmental and economical conflicts such as those associated with Glen Canyon and the Central Valley Project, Congress will legislate resolution.
2. In the case of the Central Utah Project and the Central Valley Project in California, water pricing and double subsidy may be treated in the future through water pricing.
3. The western water policy review authorized by Public Law 102-575 can produce a significant impact affecting each person who lives in the 19 western states.
4. Title XVI provides broad new authority and, therefore, opportunity to look at naturally and humanly impaired ground and surface water in the 17 western states.
5. The environmental values of the past two decades are now mainstay public values, and these values are here to stay. Our future direction needs to fully incorporate them into our programs.
6. Last, and most important to us, are our efforts over the past couple of years to refocus our mission objective through our Strategic Plan to ensure better water management objectives are fully in accord with the desire of the public.

Our challenge in the Bureau of Reclamation, and as federal agencies as we move forward into the future, is to follow a course and direction that develop solutions to the emerging issues I have mentioned. We need to evoke a thoughtful balance of water use so as to ensure sustained economic growth and the protection and enhancement of the environment. This is our challenge. The stakes are too high not to succeed. I wish us all success in this endeavor.

USDA Soil Conservation Service

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I appreciate this opportunity to provide you an overview of the Soil Conservation Service's (SCS) new initiative for providing leadership in water resource management activities. We have just completed an agency-wide strategic planning process that includes a water management component. We have involved nearly 300 employees and representatives of several organizations and agencies in developing the new strategic initiatives to improve our service as a lead national water management agency.

During our water management strategic planning process, we listened to leaders of many national organizations and other agencies interested in water resource issues. We heard a common theme from you and from a large public representing our customers. We heard that national water management programs must have:

- Strong local, state, and federal partnerships.
- Local grass-roots participation and leadership in addressing water needs.
- A watershed-based approach to water management.
- An integrated approach to water management that addresses all water and related ecological concerns.

This common theme set the stage for our strategic thinking and the development of our plans for a new direction for the administration of our water programs.

Our water management mission is *to assist people to manage water quality and quantity to meet society's evolving needs in sustainable ecosystems.* To accomplish this mission, SCS will provide technical leadership in the implementation of a nationwide water management assistance process that builds on the following principles and concepts:

- Provide water management assistance on a watershed basis.
- Promote local, state, and federal partnerships.
- Build on the existing local conservation district delivery system.
- Ensure public involvement.
- Apply integrated resource planning and management concepts.
- Utilize and build on existing data bases.
- Provide interdisciplinary planning assistance.
- Apply appropriate best available technology.
- Protect, enhance, and restore natural resources to sustain productive capability.
- Ensure shared responsibility for system implementation.
- Achieve effective use of all available financial assistance.

Our water management strategic plan has four primary components that provide a format for action in response to an array of water resource issues. This plan uses the word "watershed" to describe a planning area that is defined using hydrologic boundaries and is adjusted as needed to accommodate ground water conditions and other ecosystem needs. We are using the phrase "water management" to include actions needed to conserve, distribute, develop, protect, restore, and use water in an integrated resource management setting to achieve the optimal conditions for a specific watershed.

The first component of our strategic plan is a *leadership* initiative that will strengthen our performance as a national leader in water management. SCS administers many national programs that provide assistance in addressing water management needs. These programs are delivered in

partnership with conservation districts to ensure local and federal coordination. We work with many federal agencies to assist state and local agencies and individuals in meeting their responsibilities for water management. Actions that will be taken to clarify SCS responsibility and strengthen our leadership role include:

- Strengthen our work with state soil and water conservation and water quality agencies and conservation districts in leading the establishment of and participation in statewide coalitions of local, state, and federal agencies and groups interested in water management.
- Evaluate potential changes in existing and proposed legislation to strengthen SCS water management programs.
- Develop cooperative strategies to strengthen program implementation partnerships with other lead federal agencies.
- Identify emerging national water resource management issues and develop specific plans of action to address needs.
- Develop a plan to address the operation, maintenance, and rehabilitation needs of the SCS-assisted components of the Nation's water resource infrastructure.
- Improve water management assistance to Native Americans and limited resource individuals.

The second component establishes a *water management assistance* process through which SCS will provide water management assistance through integrated resource planning and management on a watershed basis. Water resource problems and water management systems transcend individual farms and other land management units. Future water management assistance will address the interrelated resource needs that exist within watersheds, including aquifers. Water management problem identification, planning, evaluation, and solutions will be formulated on a watershed basis and will emphasize coordination among federal, state, and local agencies and organizations and conservation districts. The delivery system to individual water users, groups, and local communities formulated in partnership with conservation districts is the unique assistance process that has made our work so effective. This concept is embodied in all soil and water resource programs that SCS administers and supports. SCS must work closely with other federal agencies and local and state organizations in enhancing this assistance process and strengthening its application in water management. Through this assistance process, SCS will:

- Implement SCS water management technical assistance through a nationwide system of watersheds that is being established.
- Provide base water management assistance on integrated resource planning and management concepts.
- Work with other federal, state, and local agencies to reach agreement on a national delineation for watershed boundaries in each state as the basis for providing water management assistance.
- Commit SCS resources to encourage the development and implementation of water management plans irrespective of agency or program.

The third component outlines actions SCS will take to use, develop, and transfer appropriate *technology* to provide water management assistance. SCS, in cooperation with a variety of organizations, must continue to develop a variety of water resource technology including measurement, evaluation, water quantity and quality model development, forecasting, standards, design, construction, and maintenance of facilities.

The extensive technical capability of SCS must now be directed to the implementation of new comprehensive initiatives to meet current water management needs. We will accelerate the development of technology to address emerging needs and share our knowledge with water users and other professionals involved in water management. The actions planned here will help ensure a cadre of professionals who have the knowledge, skills, procedures, and technical tools to successfully address water management needs and ensure timely implementation of management systems.

- Develop and execute a comprehensive SCS and conservation district employee development program in water management.
- Develop training partnerships with universities, private corporations, and agencies such as the U.S. Geological Survey, U.S. Environmental Protection Agency, Agriculture Research Service, and the

Cooperative Extension system to evaluate the fate and transport of agricultural chemicals in water.

- Accelerate the development of technology and automated systems to evaluate and program efficient water use.
- Improve technology to identify, describe, and evaluate social, cultural, economic, and other factors in water management issues.
- Advance technology in wetlands delineation and mapping wetlands restoration and enhancement, and evaluation of wetland functions and values.

The fourth component proposes *organizational* and staff changes for enhanced water management policy development and program delivery. Every SCS program impacts water resource concerns at some level. SCS organizational field structure emphasizes individual technical assistance. Significant changes may be necessary to facilitate the coordinated national delivery of total resource planning and management assistance on a watershed basis. Planned actions include:

- Organize activities to provide technical and financial assistance by watersheds, concentrating our efforts to address critical needs in each watershed, based on national and state priorities.
- Organize water management responsibilities to ensure integration of water quality initiatives and water resource project activities.
- In cooperation with conservation districts, evaluate the field office structure to identify needed organizational changes.

The SCS watershed program, authorized in 1954 by the Watershed Protection and Flood Prevention Act (P.L. 83-566) has assisted hundreds of rural and urban communities with multiple-purpose small watershed projects to promote better land use, reduce water resource problems, and improve the quality of life. These "small watershed projects" provide for resource development and help solve resource problems that are too big to be handled by individual landowners, but not extensive enough to be supported by large federal and state projects for water resource development. These projects have had a wide variety of objectives, such as flood control, land treatment, drainage, municipal and industrial water supply, rural development recreation, fish and wildlife enhancement, and water quality improvement. The program, currently about $200 million, represents about one-third of the SCS budget. The breadth of the watershed project authorities provides flexibility to address priorities.

In recent years, our watershed measures and projects have been redirected to those that enhance wildlife habitat and improve water quality. More than 55 percent of the project plans completed in the last 2 years have been for water quality improvement.

SCS state conservationists are currently preparing water management action plans to guide our work in each state in support of this new direction. We look forward to working with our partners to provide maximum public benefit through the administration of our programs in this new and challenging national water management arena.

U.S. Fish and Wildlife Service

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Introduction—The Endangered Species Act

The U.S. Fish and Wildlife Service (Service) has many programs and authorities that address conservation and restoration of fish and wildlife and their habitats on an ecosystem or watershed level. None compels us to take an ecosystem perspective as strongly as the Endangered Species Act.

Over 700 U.S. species are now protected under the Endangered Species Act, with an additional 3,000 candidates under evaluation for listing. As the list grows, so do the ramifications for landowners and land managers. Once a species is listed as threatened or endangered, any federal activity affecting that species requires consultation with the Service. The federal government frequently appears to work at cross purposes with itself when the Endangered Species Act is invoked to protect species under current or proposed management regimes on federal land. Too often federal land management has focused on doing the minimum necessary to prevent a high-profile species from being listed, or when one is listed, on doing the minimum necessary to avoid triggering jeopardy. Predictably, management aimed at the minimum and focused on glamour species does not serve well the purposes of ecosystem conservation.

Section 7(a)(1) of the Endangered Species Act (act) exhorts all federal agencies to employ their authorities in furthering the purposes of the act, and yet this authority is rarely invoked. A reasonable interpretation of this duty would include management to forestall environmental losses before they reach the point at which the full range of the act's protective measures become necessary—a point at which some of the options for efficient management commonly have been lost. There is an opportunity for all federal agencies to head off crises by considering all the elements of systems as early as possible in planning processes.

In reality, cumulative impacts to watersheds have gone unmeasured and unchecked as each of multiple jurisdictions overseeing public and private lands take parochial approaches to managing pieces of the whole. In the Pacific Northwest, logging, grazing, and mining have reduced salmonid stocks to the point that three chinook and sockeye salmon stocks have been listed as endangered, many stocks have been extirpated from their range, and a staggering 200 additional stocks are considered to be depleted. The fish are only the most recent in a progression of species, most notably the Northern spotted owl and the marbled murrelet, that are signaling to us that something is seriously wrong in the Pacific Northwest.

We have to stop working independently of one another and start taking an integrated management approach to saving these resources. In the Pacific Northwest,

we are headed in the right direction with the Northwest Forest Plan that has gathered all the players together to address comprehensively the economic and environmental issues that we allowed to reach the crisis stage.

While we must continue to support species that are already endangered or threatened, and while we must commit ourselves to dealing with the backlog of candidates and protecting those that require it, it is of vital importance that we seek ways to steward our resources so that ecosystems and species do not continue to be put at risk. We should not manage resources so that we produce and then react to an endless series of crises.

It is impossible to plan and implement the recovery of individual species if we look at each listed species and its habitat in isolation from the ecosystem or watershed in which it exists. The Service is now looking at listing and recovery of endangered species and habitat conservation planning for species on an ecosystem basis, addressing simultaneously all the vulnerable species and the factors pressuring them in a given ecosystem. Secretary of the Interior Bruce Babbitt extols the virtues of ecosystem-based management, managing for the biodiversity of entire ecosystems, intervening early, and preventing what he calls "national train wrecks."

Unfortunately, we have many examples of train wrecks. In the last 100 years, nearly half of North America's freshwater mussels have become endangered, are candidates for federal listing as endangered, or have gone extinct. The introduction and spread of the nonindigenous zebra mussel threatens to wreak even greater havoc on native mussel species. As freshwater mussels are sensitive indicators of environmental change, they are the first signal that an aquatic ecosystem is failing. Unfortunately, the decline is well-advanced, and it may be too late to restore the full breadth of aquatic biota in many of our streams.

In Texas, it took a court case to get pumpers using the Edwards Aquifer to take conservation measures to avoid the unlawful taking of several endangered species. Examples abound of inaction by resource users and managers until forced to respond by the Endangered Species Act.

So far it has taken train wrecks and the weight of the Endangered Species Act to get us all to the table. To avert these crises, we must manage a watershed as a single entity and involve federal, state, and local agencies, tribes, conservation groups, private landowners—everyone who has a part to play. We really have no choice unless we choose to wait, invoke the Endangered Species Act, and considerably reduce our options.

Species-conservation problems that are predictable based on current trends are appropriate targets for planning that seeks to avoid having conditions deteriorate to the point at which endangered-species protection is needed. The Atlantic Striped Bass Conservation Act has been extremely effective at bringing resource agencies to the table. In a truly cooperative effort between states, federal agencies, and the Atlantic States Marine Fisheries Commission, harvests were severely restricted. As a result, the striped bass population has shown signs of recovery and a limited fishery is open again.

Opportunities for this kind of planning were missed in the past with respect to species like the spotted owl and the desert tortoise, but similar opportunities present themselves today in areas where urbanization and other development are altering natural habitats. This kind of planning has the potential to allocate conservation resources more efficiently and to husband the strong medicine of the Endangered Species Act for the species and situations that truly require it.

I would like to discuss some programs and some success stories, where the Service is beginning to manage by watersheds, working with partners and implementing on-the-ground conservation and restoration measures. Many of our watershed-based partnerships have arisen either as recovery programs for endangered species or as a way to avoid ever having to list a species as endangered or threatened.

Biological Basis for Decisions in the Watershed

A solid scientific foundation is needed to underpin the management of endangered and threatened species as well as to predict future trouble spots and see that they are dealt with effectively. Managing living natural re-

sources without reference to good science guarantees future disappointment and failure. To help forecast problems and measure our successes, the Service has initiated several national resource inventory, interpretation, and monitoring efforts.

One of our newest efforts is the Biomonitoring of Environmental Status and Trends program, or B.E.S.T., which monitors and responds to environmental contaminant problems associated with fish and wildlife, concentrating on National Wildlife Refuges. Information is systematically gathered throughout targeted watersheds to provide decision makers with the information necessary to remedy contaminant problems and identify future contaminant issues long before they become acute problems.

The Service is also an active participant in the U.S. Geological Survey's National Water-Quality Assessment program. We provide the biological component to the description of our nation's surface and ground-water resources for targeted watersheds and ground-water basins. A scientific understanding of the factors affecting water quality is useful to policy makers at all levels.

The Service's National Wetland Inventory (NWI), established 15 years ago, has mapped nearly three-fourths of the wetlands in the lower 48 states and one-fourth of Alaska. NWI has provided detailed wetland maps to the public and to federal, state, and local agencies to facilitate wetland management and protection decisions. Many of these maps have now been digitized for use in other geographic information systems. NWI also conducts periodic status and trends analyses of our nations' wetlands. These analyses are critical tools for measuring the success of wetland protection programs.

The Service also is proposing a 1994 initiative to monitor the status and trends of fishery populations as a significant step to better managing all fisheries, particularly native stocks. Emphasis will be on developing a compatible sampling and reporting system in cooperation with other fisheries agencies to integrate available fisheries and habitat data into a repository from which the Service will report national status and trends information. Interactive participation by the states, tribes, other federal agencies, and the private sector is critical to the success of a national fisheries monitoring program.

The Long-Term Resource Monitoring Program for the Upper Mississippi River System is being implemented by the Service in cooperation with the States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin with guidance and overall program responsibility provided by the Corps of Engineers. The program provides decision makers with the necessary information to maintain the Upper Mississippi River System as a viable nationally significant ecosystem and a commercial navigation system.

In the interests of better and more efficient science and analysis, Secretary Babbitt is proposing a National Biological Survey that will consolidate research and monitoring within the Department of the Interior. Although many of the Service's inventory and monitoring programs may be transferred into this new National Biological Survey, the Service will continue to analyze baseline data needed to target species and habitats in peril, recommend restoration and protection measures, and monitor the success of restoration projects.

Integration of Partners in the Watershed

Effective watershed conservation and restoration requires a comprehensive approach between committed partners. I would like to discuss several areas of Service authority that use partnerships within an ecosystem to protect or restore the ecosystem.

Regulatory Activities

Our responsibilities under the Fish and Wildlife Coordination Act and the National Environmental Policy Act have involved us for many years in water project review, cumulative impact assessment, and coordination and negotiation with multiple parties in the reduction or avoidance of impacts to fish and wildlife resources within watersheds. Our approach to conserving fish and wildlife while facilitating balanced development of the Nation's transportation network, forest products resources, and energy supplies involves careful consideration of the cumulative impacts of such development.

Indeed, a major theme of ongoing sessions between the Fish and Wildlife Service and the Federal Energy Regulatory Commission is "How can we better mitigate cumulative impacts when numerous hydropower development projects occur in the same river basin?"

The Service has an important role in establishing license conditions for new and renewed hydropower licenses, under the Federal Power Act. The Service provides the Federal Energy Regulatory Commission with prescriptions to protect and enhance fish and wildlife resources when flows within a watershed are altered. Because hydropower projects are licensed for 30 to 50 years and the bulk of the Nation's projects were built 30-50 years ago, the number of projects requiring relicensing is expected to rise from 990 in 1993 to over 1,500 in 1995. This gives the Service a tremendous opportunity to redress the significant impacts hydropower projects have had on fish and wildlife resources within many watersheds.

Sections 402 and 404 of the Clean Water Act, our traditional means of addressing point source discharges and wetlands loss, focus on specific sources of pollutants and were not designed to be comprehensive. In order to fully meet the Clean Water Act's goal of restoring the chemical, physical, and biological integrity of our nation's waters, regulatory agencies have also begun taking a broader, more basin-wide approach.

The Service participates in the Environmental Protection Agency's (EPA) watershed-based process of identifying wetlands generally suitable and unsuitable for development. This identification of wetlands in advance enhances predictability in the permitting process while at the same time considering an entire watershed as a functioning ecosystem.

For example, we are partners with EPA on an advance identification of wetlands in the Verde River watershed in Arizona. Our task will be facilitated by the recently-formed Verde Watershed Commission, composed of local community members as well as state and federal agencies, whose aim is to balance the protection of resources with human growth in a watershed threatened by ground-water depletion.

Private Lands/Partners for Wildlife

The Service has established a Partners for Wildlife program that works with private landowners to restore habitats valuable to fish and wildlife. Stemming from the 1985 and 1990 Farm Bills, Partners for Wildlife has grown to include actual habitat restoration and improvement projects as well as technical assistance to private landowners.

In identifying project restoration and improvement opportunities, the Service is beginning to take a watershed approach, having realized that most habitat degradation problems can be resolved only if a healthy ecosystem is in place.

An excellent example of the Partners for Wildlife's riparian program is a series of projects on streams that are home to endangered freshwater mussels, where the Service is working with private landowners to fence cattle out of streambeds. Although the recovery programs are targeting endangered mussels, the protective measures will allow all species that depend on the stream to recover.

The Clinch River in Virginia historically has been a sanctuary for freshwater mussels: 37 species are found there, 26 of which are globally rare. Partly as a result of nonpoint source pollution from neighboring cattle farms, 13 of the mussel species have been listed as endangered and a dozen more are proposed for listing. The Service, in cooperation with The Nature Conservancy, the Tennessee Valley Authority, Tennessee Technological University, Virginia Polytechnic Institute, Department of Agriculture, EPA, and local landowners, is restoring riparian habitat with fences and buffer strips. An education and outreach program is an integral part of this restoration effort, persuading landowners to participate willingly before the river deteriorates to such an extent that recovery becomes expensive and time-consuming. Similar restoration measures are underway on other streams in the Upper Tennessee River watershed.

North American Waterfowl Management Plan

Through the North American Waterfowl Management Plan (NAWMP), the Service has entered into joint ventures throughout the country to restore waterfowl habitat. As is true in the Partners for Wildlife restoration programs, the partners

in the NAWMP have come to recognize that restoration must be on a watershed basis to be effective. For example, in the Heron Lake watershed in Minnesota, the Service cooperated with the Minnesota Department of Natural Resources, The Nature Conservancy, and the North Heron Lake Games Producers Association to develop an integrated, watershed-based strategic plan, paving the way for improved sewage treatment facilities, better water-level management, and other habitat improvements for fish and wildlife.

Interjurisdictional Rivers

The Service launched its Interjurisdictional Rivers program to correct the effects of past land management practices, recognizing that all parties have a stake in what others are doing throughout a given watershed. The Service and the numerous cooperators recognize that the conditions from mountain top to sea dictate the productivity of streams that connect the two. Three examples demonstrate the success of this program.

On the Trinity River in northern California, the Service cooperates with a multitude of partners to restore and conserve imperiled stocks of Pacific salmon and steelhead. Restoration efforts include establishing with land managers *best management practices* on logging, grazing, road-building, and recreation. The program also restores degraded spawning and rearing habitat within streambeds.

In 1991, the Secretary of the Interior signed a decision document that dramatically improved flows in the Trinity River. This flow change is the result of 2 years of multi-agency cooperation initiated by Native Americans, based on sound biological and hydrological data collected and analyzed by the Service and the California Department of Fish and Game, and resolved by a negotiation team representing the Bureau of Indian Affairs, the Bureau of Reclamation, and the Service. The key to the success of the Trinity River program is that it fixes the root problems that have affected fish and wildlife (land use practices and flow reductions), and it manipulates habitat to hasten recovery. The Service recognizes that manipulating disturbed habitat without concurrently eliminating the source of the perturbation is a waste of time and money.

The Service has undertaken a new initiative on the Missouri River entitled a Missouri River Partnership. Over the last 50 years, the river has lost 95 percent of its wetlands, 90 percent of its sandbars, and nearly all of its riparian woodlands, as a result of reservoirs and channelization. Without action, further degradation will continue, accompanied by increasing losses of fish and wildlife. The river is already host to 9 federally-listed endangered species, 41 species under federal review, and 39 species on state lists. The goal of this new program is to facilitate, in cooperation with interested governmental, tribal, and private parties, the recovery of the environmental health of the Missouri River ecosystem. The Missouri River Partnership will be a basin-wide effort with coordination among the States of Wyoming, Montana, North Dakota, South Dakota, Nebraska, Iowa, Kansas, and Missouri, federal agencies, Native American tribes, local governments, private organizations, and the public.

Another river program that employs the concept of ecosystem management is the Mississippi Interstate Cooperative Agreement (MICRA). Along the Mississippi River Basin's mainstem and large tributaries, man-made reservoirs and hydropower projects have altered flows, hydroperiod, temperature, and sediment carrying capacity, causing many native species to become extirpated from their natural range. The loss of spawning habitat and blocked migration runs are a major problem for many important riverine species, as is the spread of exotic species. The Service is assisting 28 states in assessing the Mississippi River drainage fishery resources and habitat requirements to protect, maintain, and enhance interstate fish species in the basin. A draft Comprehensive Strategy Plan has been produced establishing basinwide goals, objectives, and tasks. All 28 states have signed on as participants in MICRA, along with the Bureau of Reclamation, the Tennessee Valley Authority, and two Native American tribes, the Chippewa-Cree of Montana and the Chickasaw Nation of Oklahoma.

There are many other examples—the Colorado River, the Klamath River in California and Oregon, the Central Valley and the Russian River in California, the Chehalis River in Washington, the Connecticut River—where the Service is working with multiple partners on a watershed-wide basis to avert ecological crises and restore endangered species or prevent their listings. Restoration programs include enhanced flows on the Colorado

River for endangered fish, restoration of fish passage at dams and other blockages on the Connecticut River and in the Chesapeake watershed, restoration of spawning habitat in streams affected by logging in the Pacific Northwest, bank stabilization on the Chehalis River, and restoration of stream flows and water quality through agricultural and urban areas in California's Central Valley and in the Trinity River basin.

National Wildlife Refuges

The Service is also planning new refuge acquisitions using a watershed perspective and in consultation with our many partners. The boundaries of the proposed Canaan Valley National Wildlife Refuge in West Virginia are the origins of the headwaters of the Blackwater River. The Service does not own all the land in the watershed but is an active member of the Canaan Valley Task Force, which is composed of local residents and state and federal agencies and strives to balance human use with the protection of the valley's natural resources.

The Service is now working throughout the country with local landowners to protect aquatic habitats on national wildlife refuges that are affected by activities outside refuge boundaries.

Bay/Estuary Program

Our coastlines, with about 10 percent of the land mass, support one-third of the U.S. population. That population is projected to double by the year 2010.

Nearly half of the federally-listed endangered species depend on coastal and estuarine habitats; 30 percent of North America's waterfowl winter on the coast; and coastal commercial fisheries are worth $20 billion a year. Urban, industrial, and agricultural activities cumulatively threaten to overwhelm our coastal and estuarine ecosystems.

The Service's Bay/Estuary program was designed to address high-priority coastal watersheds as a preventative and restorative way to avert the need for listing under the Endangered Species Act. The program explicitly recognizes that restoration or conservation of these resources cannot be achieved by one agency alone, but requires extensive cooperation and partnerships with the full array of interests within each watershed. Consequently, our Bay/Estuary programs actively seek collaboration with other federal, state, and local governments and the private sector to identify and prioritize fish and wildlife resource problems, develop strategies to resolve the problems, and form partnerships to implement on-the-ground solutions.

The Service's Bay/Estuary Program is now established in nine critical coastal watersheds around the country. On-the-ground watershed projects include restoration of fish passage on over 200 miles of stream in Chesapeake Bay and Albemarle/Pamlico Sound, restoration of critical intertidal habitats along the Snohomish and Duamish Rivers and Hood Canal in Puget Sound, and restoration of 800 acres of tidal marsh habitat in Galveston Bay. These projects were made possible by our partnerships with other agencies and local interests.

The common thread running through all our resource management efforts is public involvement. Successful management requires a common goal, or vision, for the watershed. This is not always easy to obtain and requires a commitment by everyone, mutual understanding, and mutual learning. Federal legislation often forces people to come to the table. But public perception that laws are being wielded without their participation quickly becomes counterproductive. We are only too aware of the impact the Endangered Species Act is having on timber communities in the Pacific Northwest. The public is more willing to participate in an open process, where trust and ownership become the framework for consensus and compromise. With early, open participation we can be more effective in achieving a shared vision.

Future Service Directions

A new administration and the pending reauthorization of the Clean Water Act and the Endangered Species Act make this an opportune time to reevaluate existing policies and consider new alternatives.

We must work to strengthen the Clean Water Act and the Endangered Species Act to emphasize the importance of an ecosystem or watershed-wide focus and more comprehensively address the loss, fragmentation, and degradation of wetlands and other important ecosystems. A number of proposals have been made to amend the

Clean Water Act to better address point and nonpoint source pollution from a watershed perspective. Incentives may need to be provided for individual landowners and local governments to join with federal and state agencies in addressing watershed-wide issues.

A broader, more ecosystem-based approach to the Endangered Species Act would mean intervening in threatened ecosystems before they reach a crisis stage and species become endangered.

In reality, the legislation exists to meet our needs—we simply need to implement it. As mentioned earlier, federal agencies have the authority to manage for biological diversity to forestall further endangered species listings, but they rarely do. Until they begin to manage more aggressively, their options will continue to be curtailed by intervention by the Fish and Wildlife Service.

The National Forest Management Act and the Federal Land Policy and Management Act both provide strong support for management on a good deal of the federal estate to sustain ecological systems and native species. Vigorous compliance with these statutes will go a long way toward heading off the need to continue listing species that inhabit federal lands.

Other federal laws, such as the Clean Water Act, Clean Air Act, Fish and Wildlife Coordination Act, Federal Power Act, and the Federal Insecticide, Fungicide, and Rodenticide Act contain authorities that could be applied more aggressively than they have been up until now in conserving native species and natural systems.

The proposed Missouri River Basin Fish and Wildlife Restoration Bill, which has broad constituency support, may be introduced in this session of Congress. Legislation will provide a higher profile, promote the establishment of partnerships, and authorize the appropriations needed to adequately implement the initiative.

The Service has proposed a Fisheries Stewardship Initiative to begin in fiscal year 1994, to reverse the continuing decline of valuable fishery resources. The initiative was developed with the belief that piecemeal and reactive approaches to the conservation of the Nation's river resources have not been effective. The Stewardship Initiative will focus on interjurisdictional and anadromous coastal species, interjurisdictional rivers, and nonindigenous species.

The Interjurisdictional Rivers program will emphasize two rivers in 1994—the Missouri River and the Lower Mississippi River. The Service will take the lead in bringing state and local governments, federal agencies, Native Americans, environmental groups, user groups, and private citizens together to develop conservation and restoration plans for entire ecosystems. The initiative will focus on results. It is intended to reverse or minimize habitat degradation, thereby reducing the probability that species will decline to threatened or endangered status. The Service anticipates funding the restoration of at least 100 miles of riparian and instream habitat in each river basin per year.

The Service has also embarked on a comprehensive initiative to address growing concerns about the deteriorating fish and wildlife resources of the Great Lakes. In 1990, the Great Lakes Restoration Act was enacted to coordinate all parties toward restoring these valuable resources. Service field offices throughout the Great Lakes are coordinating with the states, provinces, and tribes to improve fishery habitat, with plans so far to develop and implement a lake trout health assessment on Lake Superior and to initiate restoration of Lake Superior brook trout, lake sturgeon, and walleye.

Conclusion

Effective conservation efforts require a shift from reactive to active management and the realization that ecosystem management must replace single-resource management. A watershed must be treated as the sum of all its uses and functions, including its support of living resources.

We are beginning to acknowledge that resource management in this country involves reliance on science as well as a greater coming together of individuals, groups, and organizations to achieve sustainability in natural systems.

The Fish and Wildlife Service can play a key role in interpreting natural resource information and providing the biological expertise and field presence needed in any well-rounded conservation or restoration program. We have many ongoing programs, and many proposed programs, working to restore or maintain healthy ecosystems, keep species off the Endangered Species list, and reduce the cost and the need for regulation.

All levels of government must work in harmony within watersheds, considering all tools and integrating solutions. The Service recognizes the need to forge new partnerships with a greater diversity of partners—local interests, the tribes, states, other federal agencies. We know what we get when we do not: endangered species, declining fisheries, contaminated ecosystems, drained wetlands.

Management by watershed takes a lot of effort, but in the long run it takes less effort and less money to do it now than it does to wait. The advantages are many: increased wildlife, better recreation, cleaner water, reduced pollution, and decreased flood control costs.

We extend a challenge to the other federal agencies at this conference to work together as one federal effort with the state and local agencies to avert the crises, and build a vision of sustainability in our watersheds for future generations.

New Federal Directions: Other Agencies Involved in Watershed Management

Council on Environmental Quality

Located in the Executive Office of the President, the Council on Environmental Quality has long been a strong supporter of interagency and intergovernmental cooperation and collaboration on environmental issues.

In recent years, the Council has emphasized conserving biological diversity and ecosystem management, with a focus on sustainable development. Watersheds provide ecologically sensible units for management and planning, and the Council is pleased to cosponsor a conference that explores the promise of an approach to incorporate the diverse concerns of natural resource conservation, water quality, and economic development.

Federal Highway Administration

The Federal Highway Administration (FHWA) does not directly sponsor watershed management or protection programs. However, FHWA provides an important benefit to state and local transportation agencies by protecting water quality and other watershed values through area-wide project planning, mitigation, and enhancement.

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) emphasizes the environmental aspects of transportation decision making and can lend support to watershed protection and management activities. The ISTEA requires each state to establish procedures for statewide and metropolitan transportation planning. These procedures must consider the economic, energy, environmental, and social effects of highway and other transportation improvement planning decisions.

The program also provides incentives for concurrent environmental efforts such as funding contributions to regional wetland conservation and mitigation plans. Under the Transportation Enhancement provisions, the ISTEA provides funding to mitigate water quality impacts resulting from storm water runoff. Funding is available to lessen the impacts of highway sources on overall watershed water quality problems.

National Oceanic and Atmospheric Administration

In 1972, Congress recognized the national interest in wise management of the country's coastal resources by passing the Coastal Zone Management Act (CZMA). The CZMA established a federal/state partnership dedicated to comprehensive management of the Nation's coastal resources to ensure their protection for future generations while balancing competing national economic, cultural, and environmental interests.

The 1990 passage of the Coastal Zone Act Reauthorization Amendments (CZARA) authorized an important new element—section 6217—designed to restore and protect coastal waters through the development and implementation of a Coastal Nonpoint Pollution Control Program (CNPCP) by each coastal state. These CNPCPs must consist of economically achievable, best available management measures that address all significant sources of nonpoint source pollution within many coastal watersheds.

The Office of Ocean Resources Conservation and Assessment (ORCA) provides data, information, and knowledge for decisions affecting the environmental quality and natural resources of the Nation's estuarine, coastal, and oceanic areas. Since the early 1980s, ORCA has used watersheds to gather information and produce assessments and atlases. However, over the last 5 years, ORCA has increased efforts to characterize and assess watershed resource use status and conflicts. Programs such as National Status and Trends (NS&T) and components within the Strategic Assessments Program (e.g., National Estuarine Inventory, National Coastal Pollutant Discharge Inventory, National Shellfish Register, Estuarine Living Marine Resources Program, and the new Estuarine Eutrophication Survey) use the watershed as the basic spatial unit to organize and analyze data.

ORCA's new Coastal Assessment Framework (CAF) is a set of digital boundary files that define more than 140 major estuarine watersheds draining the Nation's marine and Great Lakes coasts. It will serve as the spatial basis for further NOAA efforts to improve the agency's national estuarine assessment capability and is available to users upon request. As federal and state regulatory and management programs increasingly adopt a watershed approach, ORCA will continue to expand its use of watersheds as the fundamental spatial unit to organize, analyze, and present coastal resource information.

ORCA and EPA are jointly conducting, monitoring, and assessing programs in coastal watersheds. EPA's Environmental Monitoring and Assessment Program (EMAP) emphasizes indicators of ecosystem health, while ORCA's National Status and Trends Program focuses on the presence of chemical contaminants and contaminant effects in mussels, oysters, fish, and sediments at almost 300 sites in U.S. coastal waters. A major step in developing a comprehensive, unified EPA-NOAA program to assess the condition of the Nation's estuarine resources is being initiated in the Carolinian Province beginning this summer.

National Park Service

Through the Rivers, Trails and Conservation Assistance Program (RTCA), National Park Service staff help public agencies and citizens assess their natural, recreational, and historical resources; promote citizen planning; develop compelling visions and realistic plans; promote partnerships; and find the resources needed to achieve conservation results.

The scope of this assistance is being shaped, in part, by the watershed protection movement. Recently, RTCA has helped communities expand their local river corridor projects to promote a broader watershed vision. RTCA has also taken on the challenge of fostering grass-roots conservation projects in large metropolitan areas, where urban stream restoration will likely be a major component in future efforts.

In both metropolitan and rural areas, RTCA-assisted state and national river assessments will generate valuable information for organizations and public agencies preparing watershed plans. As RTCA moves from corridor projects into broader landscape protection efforts, the challenge remains the same—how to ensure that the needs and desires of local communities shape resource protection.

Tennessee Valley Authority

Cleaning up the Tennessee River is an ambitious goal. But by expanding cooperative efforts with other government agencies, individual citizens, and private organizations, the Tennessee Valley Authority (TVA) thinks it can be done.

TVA's Clean Water Initiative is a partnership approach to preventing and cleaning up pollution. TVA works with others to identify pollution problems and find and carry out solutions. TVA contributes to this effort by monitoring water quality conditions, assigning teams of water resource specialists to targeted watersheds, and helping to develop new ways to protect water quality without limiting the river's use.

TVA has developed the most comprehensive monitoring program in the country. TVA scientists monitor conditions at key locations on most of the 35 lakes in the Tennessee River system and check the water flowing in from major streams. This information, combined with data collected by others, is used to draw attention to pollution problems, set clean-up goals, and measure the effectiveness of water quality

improvement efforts over time. TVA also monitors aquatic plant and mosquito populations around its lakes to help target management efforts.

Multidisciplinary teams of water resource specialists are beginning to work in the Tennessee River's major watersheds. They look at all sources of pollution affecting lakes and streams in the area, taking special note of unique and valuable resources that need protection. They pinpoint problems, identify effective solutions, and bring together the people and organizations necessary to improve the health of the water resources in each location.

As river action teams identify specific water quality problems, TVA scientists work to develop new solutions. They are constantly looking for more efficient and effective methods to control pollution and manage aquatic plants and mosquitos.

U.S. Bureau of Land Management

The U.S. Bureau of Land Management (BLM) is moving to an ecosystem-based approach to multiple use management of natural resources on public lands. This approach involves the integrated management of resources based on consideration of values and uses within an ecosystem. Management is accomplished under the concepts of multiple use and sustained yield as established in the Federal Land Policy and Management Act. In accordance with this new approach, management programs are presently undergoing significant revision.

As a part of this effort, BLM currently employs three national strategies to improve riparian/aquatic management efforts. All three strategies recognize and emphasize integrated watershed management to achieve their goals. The first, under the PACFISH initiative in the Pacific Northwest, is a watershed-driven approach that emphasizes the maintenance and restoration of salmon stocks. Management activities in specially designated riparian areas are permitted as long as they are compatible with objectives developed for those sensitive areas. The second strategy, "Bring Back the Natives," is a national effort to restore the health of entire riverine systems and their respective native aquatic fauna. Both of these strategies include the recovery of water quality and stream health as the true standard of overall watershed restoration. The third, the riparian/wetland initiative, recognizes the special importance of these ecosystems within watersheds and establishes their management and improvement as a priority for the BLM.

USDA Extension Service

The USDA Extension Service (ES) works cooperatively with 74 land grant universities in 50 states and six territories. It provides education and promotes voluntary adoption of water quality practices through 16 USDA demonstration projects and 74 Hydrologic Unit Area projects that focus on agricultural watersheds.

Education programs are conducted in many EPA estuaries such as the Chesapeake Bay. ES also funded Farm*a*Syst, which assesses rural wellhead protection in 40 states. A national data base of watershed instructional materials can be accessed through Purdue University, and an assessment of youth instructional materials has just been completed through the University of Wisconsin.

U.S. Geological Survey

In 1991, following a 5-year pilot effort to test and refine assessment concepts, Congress appropriated funds allowing the U.S. Geological Survey to begin a multiyear transition to a fully operational National Water Quality Assessment (NAWQA) program. Program goals are (1) to describe the status and trends in quality of a large representative part of the Nation's ground and surface water resources and (2) to develop an understanding of the natural and human factors affecting the quality of these resources.

This information provides sound, nationally consistent water-quality information on which governments can base water resources decision making. The program will integrate water-quality information on local, regional, and national scales. In 60 key areas, rotating investigations of the surface and ground water resources of major regional hydrologic systems will be conducted. In 1991, assessment activities began in 20 areas. Assessment activities are planned in 20 additional areas in 1994 and 1997.

The NAWQA program will address a wide range of major water-quality issues. One concern—to be addressed nationally during the program's early years—is the relation of pesticides to agricultural management practices, factoring in climate, geology, and types of soil. This information will be useful to land and water resources policymakers and managers.

How to Finance Watershed Protection and Design a Land Acquisition Program

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Water Resource Management Is Fragmented

The waters of the Nation are regulated, monitored, extracted, and discharged within a complex web of federal, state, and local programs. Rarely are the Nation's waters approached holistically, with recognition of their values and contributions:

1. Their natural value within local, regional, and continental hydrological and ecological systems.
2. Their economic worth as community water supplies.
3. Their waste treatment capability to accept and assimilate pollutant loadings.
4. Their intrinsic relationship with the surrounding watershed that often dictates both the quality and quantity of the resource.

The programmatic compartmentalization of water resources management is rationalized in many ways:

- *The bureaucratic justification.* Large organizations need to simplify complex systems in order to regulate them.
- *Financial considerations.* Programs are organized around funding allocations.
- *Historical precedent.* Certain aspects of water resource management, such as land use in watersheds, have been considered the prerogative of local government and landowners and therefore outside the purview of major bureaucracies.

The arbitrary breakdown of water resources into distinct subsets (e.g. surface water, ground water, coastal water, wastewater, etc.) makes it difficult to reassemble the resource, programmatically, into a whole. This problem is compounded because, overall, water has no generally agreed upon economic value. This means that the effort involved in protecting and managing water is motivated by the "common good" rather than by economic forces that may ultimately be more effective and efficient.

Water Should Have Some Basic Economic Value Reflected in Its Price

Under current practices, those who take the Nation's water, generally, take it for free. The economic value of water is based upon the various costs associated with treating and delivering the water to the consumer. By comparison, oil producers pay royalties to oil field owners, so from the beginning of the extraction process, oil as a commodity has a quantifiable economic value.

In order to gauge the size of the task involved in comprehensive water resource management, one can begin by looking at the financial needs associated with the two major water programs: drinking water and wastewater treatment. A substantial gap

exists between the capital needs of these two major programs and the funds likely to be available in the near term. Nationally, the capital needs for just drinking water and wastewater treatment for the years 1993-2000 are estimated to reach $167 billion. Projected available funds for these years are approximately $88 billion, creating a $79 billion shortfall. (*America's Environmental Infrastructure*, 1990). These projections do not begin to address the other aspects of a comprehensive water policy such as watershed protection or nonpoint pollution programs.

It is now time to begin to rethink how to manage the Nation's water in a comprehensive way and to develop a new system for paying for this comprehensive, integrated approach. One idea receiving attention is the concept generically known as "green taxes." These are usually user fees added to commodities and practices that encourage those who pay to do the right thing, environmentally, while also generating much-needed new revenue to pay for environmental initiatives. Just such a concept was discussed in a recent *New York Times* article, "Cheapest Protection of Nature May Lie in Taxes, Not Laws" (*New York Times*, Science Section, November 24, 1992, C-1, C-8). The *Times* article points out that ". . . taxes that penalize polluters could make the economy fitter and leaner, even as it makes the environment cleaner." However, the article also notes that

> . . . what works well on a black board, however, may not work as well in practice. . . . Externalities are often hard to measure . . . and . . . even harder to assess. That explains, in part, why the political impulse is to regulate away externalities rather than to ask offenders to internalize the cost. . . . It should not be surprising, then, that America's sweeping environmental laws governing air, water, solid waste . . . leave little room for market-based environmentalism. Standards are generally set according to what is deemed safe, aesthetic, and technologically feasible. And, they are enforced with civil and criminal sanctions intended to deter, not to offer the polluter a chance to pay and play.

The selling and trading of "water rights" in the American West is one example of a market-based system that rigorously allocates the water resource. But under the doctrine of "use it or lose it," this approach has not fostered water conservation or protection. Even when the market is applied to water, the thing of value is the "right" to the water, rather than the water itself. By this example, we see that a valueless commodity is naturally wasted.

The way we use water would inevitably change if we placed some value on this essential resource. On the extraction side, by pricing water in a way that better reflected its value to us as well as the true cost of protecting and managing it, we would slowly improve our ability to fund protection efforts and also create a financial incentive to use water more wisely. On the discharge side, making those who pollute pay a fee that reflects the benefits received and the damage created is a sensible one. The polluter pays approach is already embodied in both the Clean Air Act of 1990 and in solid waste landfilling practices. In both cases, the waste discharger pays a discharge fee based upon the volume and the dangerous nature of the waste loaded into the environment.

Using Pricing to Fund Better Water Management: The New York Plan

In New York State, the issue of comprehensive water resource management has been examined in detail by the state's Water Resources Planning Council. From this effort, a legislative proposal has been generated which attempts to address water holistically by applying a market-based approach to create financial incentives for wise water use. The goals of the program include:

- Adequate funding for all state agencies involved in water resource management.
- A steady stream of revenue not tied to the state budget fluctuations.
- A system that creates financial incentives for decreased water use and cleaner discharge.
- A funding stream going back to local governments and industries to meet specific water-related needs like sewage treatment plants, drinking water supply, pollution abatement, and toxic use reduction.

- Money for infrastructure expansion and maintenance.
- Watershed planning, management, and protection, including land acquisition.
- Incentives for water conservation.
- Nonpoint source pollution funding.
- Basic and applied research on water and wastewater issues
- Computerization of the state's water-related data base using GIS technology.
- A strategy to gradually improve water quality and reclassify waterbodies as they recover.
- Funding to remediate severely impacted waterbodies.
- A system which will eliminate certain persistent toxics from the waste stream using periodic escalation of discharge fees that internalize the costs of specific toxic discharges.
- A program for funding of infrastructure projects that can create jobs and boost local economies.

The Water Resources Management and Protection Act, proposed in New York State, will generate revenue for a dedicated fund derived from fees on pollutant loadings and water use surcharges. The fee system will be pursued in conjunction with the existing regulatory structure of the NPDES and water supply permit programs. Thus, a permitted discharge or water withdrawal will remain constrained by the conditions of the permit but the affected user will have to pay for the mass of pollutants discharged and the quantity of water used.

Justification of the fund is threefold:

1. The ultimate goal of the Clean Water Act was, and continues to be ". . . to restore and maintain the chemical, physical and biological integrity of the nation's waters." Existing water quality standards and effluent requirements were to serve as interim guidelines, not ultimate goals. This fund represents another tool to be utilized toward the achievement of the ultimate water quality goal.
2. The discharge of wastewater, in effect, employs the receiving waterbody as a final treatment process, thus, a fee represents a bill for services rendered.
3. Water is an essential and limited resource that must be conserved for all uses and users, and the fees represent part of the costs associated with maintaining and protecting that resource.

Above and beyond the environmental and economic benefits to be derived, the fee system would be vastly more equitable with respect to funding of water programs. To date, the majority of funding for water resource protection has been derived from general revenue funding and, as a result, fails to reflect the relative benefits received. Under this proposal, the funding would be derived from those who benefit from and/or abuse the resource, and the charges would be proportional to the benefit and/or the abuse. In a sense, this is an attempt to extend the premise of the "responsible party pays."

The fund would be produced by a fee system comprised of two major components.

1. *Water withdrawal.* The water withdrawal fees consist of a base fee applicable to any withdrawal greater than 62,000 gallons per day and one million gallons per year, and a conservation surcharge fee on consumptive or unaccounted-for-water uses.
2. *Pollutant loading.* The pollutant loading fees are levied on significant major discharges and will be based upon the mass loading and toxicity of the compounds released. A list of regulated discharges is created and a loading fee allocated to each loading, mainly based upon the toxic weight assigned to the discharge. Persistent toxics and those most damaging to the environment have the highest toxic weights.

The water withdrawal fee, based on the most typical water use, public water supply, is set at 6 cents per 1,000 gallons. This fee in conjunction, with fees collected from other users, will produce approximately $150 million annually. The cost impact on the consumer is about $2.00 per person per year more than current water bills. Extrapolating this approach nationally, the Clean Water Council projected that a water user fee of 14 cents per 1,000 gallons could generate over $17 billion during the 1993-2000 period. The Council estimates that, based upon per capita consumption of 105 to 140 gallons per day, such a fee would increase a household water bill annually between $13.41 and $17.89.

The wastewater loading fee would generate about $120 million annually in the

early years and would gradually decline as high-cost discharges are eliminated. This fee would increase the average citizens sewage discharge bill by about $11 annually. Using a slightly different approach, based just on volume, the Clean Water Council projected that a national fee on wastewater discharges at the rate of 35 cents per 1,000 gallons could generate an additional $37 billion over 8 years.

The revenue generated from the fee system will be bonded over a 15-year period to produce a $400 million per year program. The funds will be used for the following activities:

1. Water supply and wastewater projects, through low-interest loans, estimated at $270 annually.
2. Water resources remedial action plans, through 50/50 cost-share grants, estimated at $180 million annually.
3. Watershed protection projects, including planning, management and acquisition, estimated at $90 million annually.
4. Research projects including a statewide GIS system, estimated at $1 million annually.
5. State program administration aid totaling about $30 million annually.
6. Nonpoint source pollution program to be developed and funded, estimated at $6 million annually.

Making the Most of Watershed Acquisition Funds for Water Supply Protection

One of the most important aspects of water resource protection is addressing the management of the watershed. A model program for watershed management has been developed in Suffolk County, Long Island, NY. This program was the most ambitious land acquisition program at the local level ever undertaken in this country. Funded by a sales tax of 1/4 of a cent, it was intended to purchase up to 20,000 to 25,000 acres of land for ground-water protection on a revenue base of $300 million. A shortfall in revenue produced the purchase of approximately 7,000 acres of land from a revenue base of $135 million. As part of the program, a model for how to develop an effective watershed acquisition program was created. This model can be replicated statewide once the statewide Water Resource Management and Protection Act is adopted.

The Suffolk County Land Acquisition Committee reviewed the approaches used in other areas and eventually rejected a numerical scoring approach for deciding which land to buy. Instead, the Committee identified over 1,000 candidate parcels within the legal buying area identified in the program. The privately held candidate sites along with existing public holdings were painstakingly mapped with a GIS. Recognizing the unique qualities that were often distinctly different from one area of the county to the other, the Committee designated 17 "sub-watersheds" within the larger watershed protection zone. In formulating a specific purchasing strategy, the Committee defined six guiding principles:

1. Identification of watershed acquisitions strictly, or solely, upon a parcel-by-parcel basis must be avoided. Rather, delineations of specific, critical sub-watershed regions must be the primary task.
2. Since high-priority watershed regions will be located in areas of the county that are distinct from each other with respect to hydrology, ecology, land use, population, water supply infrastructure, real estate markets, and other factors, no evaluation scheme can be endorsed, however intuitively appealing, which compares individual parcels in one watershed region with those from other regions.
3. Comparisons among the subwatersheds must focus upon watershed-level attributes.
4. Candidate parcels within an individual sub-watershed should only be compared against their "peers" (i.e., other parcels within that sub-watershed).
5. Criteria used to select strategic parcels within sub-watersheds will vary from one sub-watershed to another. In all cases, the overriding goal is to ensure the best possible protection for the sub-watershed.
6. The establishment of sub-watersheds provides a land evaluation methodology:
   a. To clearly separate regional from local criteria (i.e., uses information at different spatial scales properly).

b. To permit qualitative and quantitative information to be combined without artificial numerical conventions.
c. To make subjective values and judgments explicit.
d. To yields results which are easily presented, understood, and discussed.

By using the sub-watershed approach, the committee was able to maximize the available land for purchase within an organized system that understood which parcels were necessary to achieve total or majority protection of a particular sub-watershed. This avoided a shotgun approach resulting in a number of parcels that did not fit within any particular protection scheme. The sub-watersheds reflect the patchwork reality of the present-day landscape: variable-sized open space tracts within a matrix of predominantly developed land. As such, they represent the best remaining assemblage of opportunities for building large, contiguous, protected tracts of watershed lands in the county. Within each sub-watershed, one or more "keystone" parcels can be defined. Keystone parcels are those sites which are crucial to making a sub-watershed work. They may be single parcels or a collection of several contiguous lots which, when taken together, secure the essential features of the sub-watershed.

The selection of sub-watersheds is reflected by which keystone parcels are secured. In some cases, the size of the sub-watershed is sufficient to permit several keystone choices. In small sub-watershed, the loss of the keystone may cause the loss of the entire sub-watershed. Thus, choices of ultimate keystone acquisitions reflect policy, resources and availability factors that will converge when making the protection of sub-watersheds a reality.

A program for addressing water holistically, especially utilizing market forces as incentives and having a clear strategy for watershed protection, as well as land acquisition, can make the waters of the Nation clean once again.

Financing of Nonpoint Source Pollution Abatement Projects Through Ohio's State Revolving Loan Fund

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In 1987, when Congress reauthorized the Clean Water Act, it established a state-level revolving loan fund (SRF) program to finance not just construction of municipal wastewater treatment projects, but also two new areas: the implementation of nonpoint source (NPS) pollution management programs, and the development and implementation of estuary conservation and management programs. Additionally, authority was established to provide loans to individuals for these types of projects. Nationally, however, states have had difficulty finding a mechanism to provide this financial assistance.

At the state level, the Ohio Environmental Protection Agency (EPA), Division of Environmental and Financial Assistance (DEFA), has been developing the ability for Ohio's SRF, *The Ohio Water Pollution Control Loan Fund* (WPCLF), to fund NPS pollution control projects. The WPCLF is administered jointly by DEFA and the Ohio Water Development Authority (OWDA). We believe that we have found an effective mechanism for financing NPS pollution control projects through the use of a *linked deposit* concept. This financing mechanism may have applicability in other state SRF programs.

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Project Development

The continuing outcry for better funding and more responsive aid for NPS problems encouraged Ohio EPA staff working in the WPCLF program to identify NPS projects that could be funded through the program. Ohio's multi-agency section 319 grant selection committee, composed of representatives from Ohio EPA's Division of Water Quality Planning and Assessment (DWQPA), the Soil Conservation Service (SCS), and the Ohio Department of Natural Resources (ODNR) recommended the Killbuck Creek watershed, based on need and the local support a project would receive in that watershed. This project is serving as a pilot for developing a NPS funding component for the WPCLF.

The Killbuck Creek watershed (Figure 1), located mainly in Wayne and Holmes counties, is 310 square miles in area and is situated on the gently rolling Western Allegheny Plateau, an area highly conducive to dairy farming and general agriculture. Dairy farming is the main agricultural activity in this watershed, which is first in Ohio and fourteenth in the Nation in terms of livestock density. As a result of its ability to support farming, the watershed has been greatly affected by nonpoint agricultural pollution sources. Problems with manure handling and livestock watering in the streams are the main sources of agricultural nonpoint pollution in the watershed.

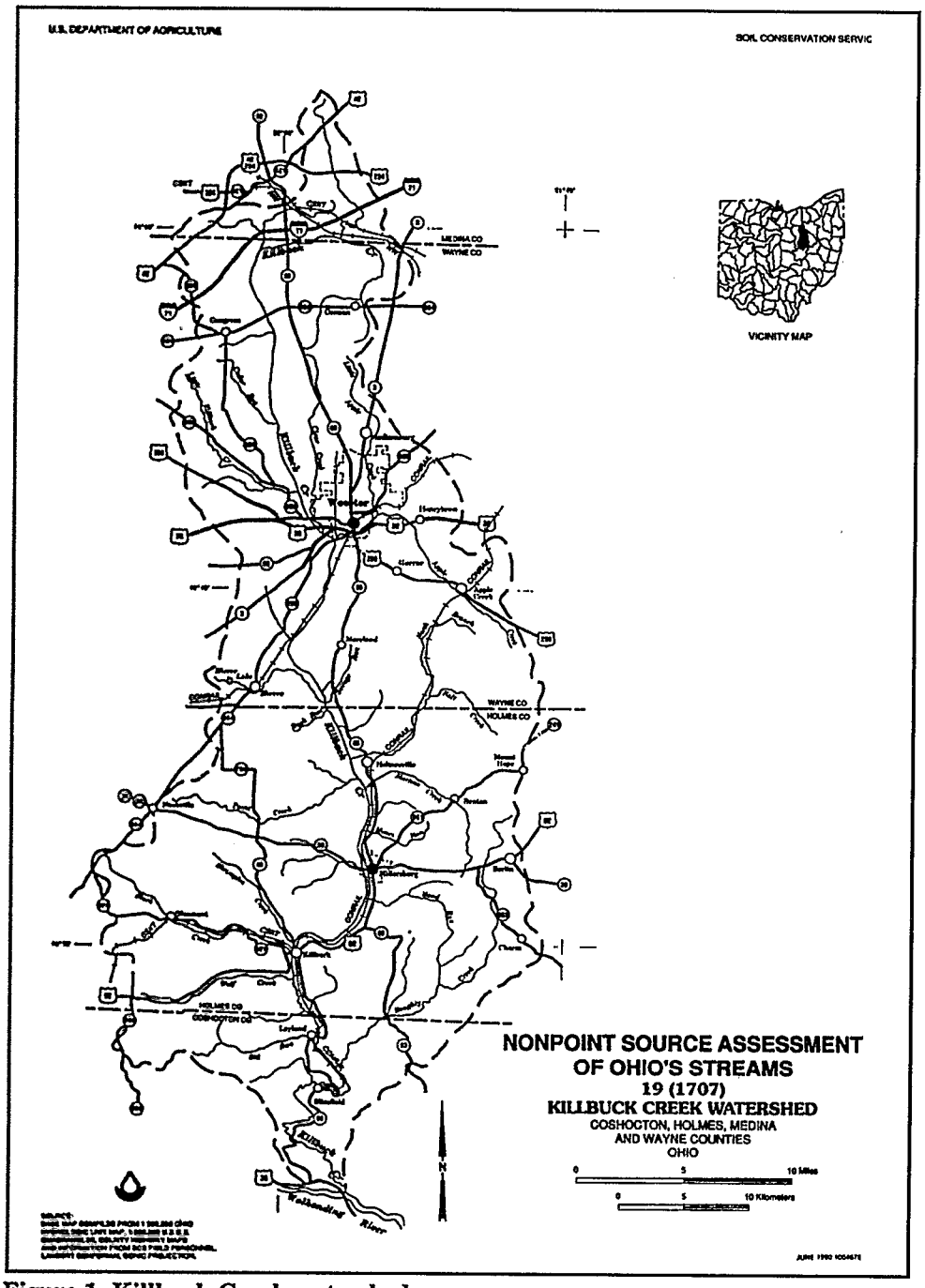

Figure 1. Killbuck Creek watershed.

The project was identified as a good candidate for WPCLF financing as some work had already been done in the watershed by other agencies. This effort to implement a watershed plan in the Killbuck Creek area has attracted other agency funds and mobilized greater local participation in the project. The primary basis for initiating this project was Ohio's Nonpoint Source Assessment report, which identified stream segments in the watershed as either impaired or impacted by nonpoint source pollution. Stream littering violations were being issued by the local game protector to farmers in the watershed at the time we were informed about the project.

Locally, the focal point for developing and implementing a watershed management plan to control agricultural pollution is the Soil and Water Conservation District (SWCD) boards in Wayne and Holmes counties, along with their associated SCS staffs. Assistance in project planning is also being provided by the Ohio State University Extension, ODNR, and Ohio EPA, as well as local health departments, county governmental and planning representatives, teachers, and various other agricultural groups in the area.

We are currently developing a watershed management plan in conjunction with these groups. This watershed management plan will:

- Define the problems in the watershed.
- Identify the types of improvements that will work best to address the problems.
- Define the development and approval process for projects.
- Define how project construction and implementation will be administered.
- Define how the watershed will be monitored to determine the success of the funded improvements in addressing water quality problems.

There will also be an education and information component in this process to inform farmers about the water quality problems in the watershed and how their farming prac-

tices contribute to these problems, as well as the availability of WPCLF linked loans.

Once the watershed management plan has been completed, farmers in the watershed interested in receiving financial assistance will, with SCS technical assistance, develop conservation management plans for their farms which are consistent with the watershed management plan. The conservation management plans will establish schedules for implementation of improvements. The farmers will enter into long-term agreements with SCS to comply with the conservation management plans. After approval of the conservation management plans by the SWCD boards, cooperating farmers will then be able to apply to participating local banks for WPCLF linked deposit loans. We anticipate that the first of these WPCLF linked deposit loans will be made in August 1993.

Linked Deposit Concept

The linked deposit concept is the unique aspect of this project, and is a model which we borrowed from the State of Ohio Treasurer's Office. The treasurer, through the *Mary Ellen Withrow Linked Certificates of Deposit Program*, is currently providing funds to local area banks to be used for agricultural production loans or small business loans. The State Treasurer invests state funds with qualifying participating banks at below market interest rates through the issuance of a certificate of deposit. The banks then pass on the lower interest rates provided to them by the state treasurer by proportionally reducing the interest rates of the loans made to farmers or small businesses. The certificates of deposit are insured by the FDIC, or secured by the bank's assets when investments exceed $100,000.

The linked deposit model holds the following advantages for the WPCLF program:

1. Because of the popularity of the State of Ohio Treasurer's program, local banks are already familiar with how a linked deposit program operates. This will facilitate the entry of the WPCLF into this new area of project funding. Local banks from the Killbuck Creek watershed area have expressed an interest in participating in a WPCLF linked deposit program. This interest will be a key component of implementing the program.
2. The individual credit decisions that need to be made on farm loans will be made by institutions that have experience in making such loans. This greater familiarity with making farm loans will result in better credit decisions being made.
3. The WPCLF will be sheltered from the credit risks associated with making loans to individual farmers. The banks will assume those risks and the WPCLF's security will derive from either insurance through FDIC, or the assets of the banks in cases where deposits exceed $100,000.

We are planning to use the following process to implement WPCLF linked deposit financing:

1. Banks would initially indicate an interest in participating in the program.
2. Interested banks would be evaluated regarding the security they could provide, their financial health, and whether or not they are state chartered institutions.
3. For interested banks meeting the qualifying criteria, agreements would be entered into covering acceptable uses and forms of security for WPCLF funds deposited in the banks, as well as limitations on the percentage of public funds that can form a bank's assets. The banks would commit in the agreements to pass the discount they receive from the WPCLF funds deposited in the bank onto the recipients of the *linked deposit loans*.
4. As farmers bring in approved farm management plans to participating banks, the banks would evaluate the farmers' loan applications based on the banks' loan criteria. After loan agreements are entered into between the banks and the farmers, the banks would come to the WPCLF with a request for funds. The WPCLF would then deposit funds in the bank at a reduced interest rate.
5. The term on WPCLF linked deposits would be equal to the useful life of the facilities for which loan funding was provided.

Conclusion

In the Killbuck Creek watershed, developing the ability to finance agricultural NPS pollution controls through the state's SRF program has forged new networks which are bringing together public and private entities in a new financing partnership. The skills and resources of many agencies, groups, and individuals are being focused in a coordinated effort to address a watershed-scale problem. Ohio is finding that with its SRF program it can augment previous activities, supply badly needed funds, and facilitate development and implementation of watershed-level projects that provide water quality benefits. In Killbuck Creek, placing responsibility for making decisions about project implementation and financing at the local level will greatly increase the chances of success for the project. We feel that this is one of the chief benefits of the linked deposit method of financing.

Besides the livestock problems initially identified in the Killbuck Creek watershed, problems with unsewered areas and landfill leachate have also been mentioned by the SWCD boards of supervisors. These problems may also be addressed in a later phase of this project. For the unsewered area problems, if upgraded septic systems are a solution to the problems identified, the WPCLF linked deposit concept may also provide the best financing mechanism to help solve these problems.

The Killbuck Creek watershed project demonstrates some important principles in the effective delivery of government services. The Killbuck Creek project is being designed to utilize people at the local level who are most knowledgeable about solving agricultural pollution problems and arranging financing with individual farmers; namely, the local agricultural organizations and local area banks.

Other NPS pollution control projects currently being considered as candidates for WPCLF funding include other types of agricultural pollution controls, on-site septic system improvements, landfill closure plans, and wellhead protection. In each case, different financing approaches may be needed to implement improvements. We expect that these activities will result in comprehensive watershed-level projects, combining our efforts with those of other government agencies. Broad-based water resource restoration projects will be the result of tailoring financing and implementation plans to local needs.

Update

On December 23, 1993, the U.S. Environmental Protection Agency (EPA) formally approved Ohio EPA's linked deposit concept as consistent with the federal Clean Water Act. This approval and U.S. EPA's concurrence with Ohio's subsequent amendment to its Nonpoint Source Management Program now allow Ohio's WPCLF to finance NPS projects in the Killbuck Creek watershed as described above.

In response to this approval, two linked deposit loans have been made to farmers in the Killbuck Creek watershed. These capital improvements are valued at $140,000. Ohio EPA expects further application of the linked deposit concept by other farmers and in other watersheds in 1994.

Financing Storm Water Management: Maryland's Experience with Storm Water Utilities

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Motivation for Dedicated Local Funding

Maryland's 1982 Stormwater Management Act (Environment Article, Title 4, Subtitle 2) required counties and municipalities to adopt an ordinance by 1984 giving them the authority to implement a local storm water management program. The Act also requires the Maryland Department of Environment (MDE) to evaluate each jurisdiction's program at least once every 3 years. Thus, to effect changes at the local level, the state must do so through these local program reviews.

The state has two standard tools available for influencing local programs: enforcement actions and incentives. Unfortunately, these tools are inadequate. Formal enforcement orders are viewed as being counterproductive. Consequently, state staff take action through less formal written recommendations with spotty success. Financial incentives, which had been limited in the past, have eroded further due to state budget constraints. The MDE has concluded that instituting dedicated long-term local funding mechanisms is the logical solution to the problem of ineffective storm water management programs. This paper discusses the efforts made by MDE to help local storm water program managers overcome the obstacles to meeting their financing needs.

As noted above, state incentives are a limited and unreliable source of local program financing. Until recently, Maryland had three funding support mechanisms that were available to local storm water management programs: the Storm Water Pollution Control Cost Share Funds, the State Revolving Loan Fund, and Storm Water Grants-in-Aid. The Cost Share Funds and Revolving Loan Fund are geared toward funding the construction of public storm water management structures. The Revolving Loan Fund was designed for large-scale water treatment projects. The significant administrative burden associated with securing these funds makes it unattractive for storm water management structures, which are small by comparison to water treatment plants. Prior to its termination, due to state budget cuts, the Grants-in-Aid program was used by local governments to hire staff for their storm water management programs. This grant program played two important roles. First, it helped some jurisdictions keep up with plan reviews, rather than performing perfunctory reviews. Second, the potential for losing the grant money served as a strong incentive to be responsive to the state's concerns.

Figure 1 illustrates two salient points based on 1990 data provided by the local jurisdictions. The two pie charts, which portray per capita revenue sources, differ by the inclusion and exclusion of the revenues of Prince George's County, a suburb of Washington, DC. Prince George's County is the only county in Maryland that has a dedicated funding source for its storm water management program (that is, a dedicated property tax). The first point illustrated by comparing the two charts is how much

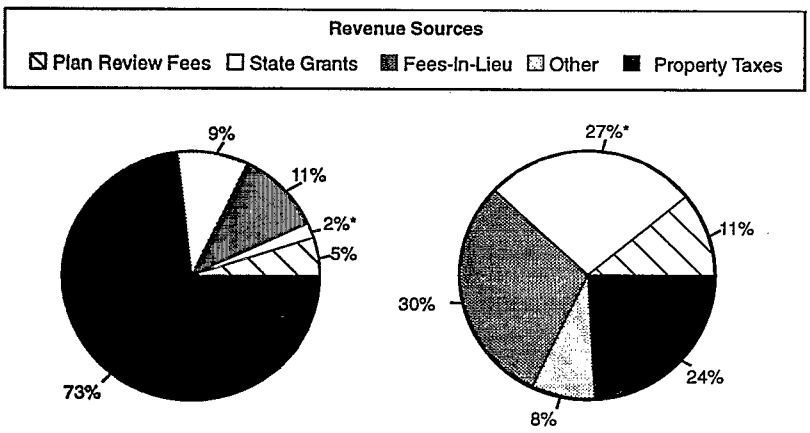

Figure 1. Comparison of per-capita operating expenditures by revenue source for storm water management in Maryland including and excluding Prince George's County.

Prince George's County's well-financed program dominates the funding of the other counties. The second point made in Figure 1b highlights the impact of losing the State-Grants-in-Aid program, which represented 27 percent of statewide county funding after excluding Prince George's County. Of the 23 counties in Maryland in 1990, 4 depended on the state grant for 100 percent of their storm water management program funding. The state grant monies provided 50 percent or more of the funding for 11 counties in Maryland.

In 1986, state staff completed a storm water facility maintenance survey. The survey results made clear that maintenance funds were subject to redirection to cover more pressing funding needs. Some jurisdictions charge developers a fee in lieu of building on-site storage facilities and set this money aside to fund the future construction of a regional pond. Unfortunately, these funds can also be redirected away from their intended purpose. Thus, in addition to the basic recognition that additional local funding was needed, evidence of the instability of storm water management funds prompted the state to examine a utility approach. This approach would create local enterprises with the authority to charge fees that correlate with each property owner's contribution to the storm water problem. The revenue collected by a utility would be insulated better from the vagaries of the political process and thus more secure.

Storm Water Utilities and Other Dedicated Revenue Sources

Most of the 100 or so storm water utilities in the United States are public entities, much like conventional water utilities, that provide storm water management services. Landowners are assessed fees based on land characteristics such as area and the degree of impervious development. In a proposed rate schedule developed by the Water Resources Planning staff in Montgomery County, Maryland, a pollution loading factor is also included.

Storm water utilities are frequently compared to dedicated property tax approaches (an ad valorem tax), which is about the only other means of generating a large steady supply of revenues. Five primary benefits of the storm water utility approach have been identified. First, they can generate substantial funds. Second, the funds are predictable and secure. Third, the paying public can readily account for the use of their fees. Fourth, storm water utilities that give credits for on-site controls provide an incentive for environmental protection. Finally, the distribution of costs are considered to be more fair than a dedicated property tax in two ways. The first way is that fees are related to environmental impact rather than an arbitrary land value. In addition, a study conducted by MDE (George, 1991) suggests that the distribution of costs among different land uses based on a storm water utility system weigh more heavily toward commercial land than they would under a property tax scenario. This distribution is more equitable because commercial land owners have the opportunity to pass their costs on to customers, whereas residential landowners cannot.

There are several drawbacks of storm water utilities when compared to a dedicated property tax approach. First, a property tax is usually easier to initiate. Starting a utility can require a significant process of educating decision makers and the public. Second, utilities entail additional administrative

operating costs due to significant database maintenance requirements. Third, because property values generally grow over the long term, a property tax approach is less likely to require politically painful fee adjustments to keep pace with inflation (if property values decline, this could be a drawback). Finally, property taxes are deductible when computing income taxes, whereas utility fees are not.

The State of Maryland is aware that each jurisdiction has unique considerations underlying its choice of how to finance storm water management programs. Over the past 6 years, MDE has provided technical assistance to encourage local governments to adopt some form of dedicated financing. The following section highlights these efforts.

Maryland's Storm Water Utility Technical Assistance Efforts

Maryland's storm water utility technical assistance efforts began in 1987 with an intensive literature search and survey of existing utilities. In 1988, two significant reports were produced by the MDE. *A Survey of Stormwater Utilities* (Lindsey, 1988a) provided the results of a survey of 25 existing utilities. The findings demonstrate the wide variety of existing utilities and give answers to commonly asked questions. *Financing Stormwater Management: The Utility Approach* (Lindsey, 1988b) describes the technical, legal, and public policy issues associated with planning and implementing a storm water utility. It also includes a fairly extensive reference list. These two documents serve as the primary references for a recent American Public Works Association publication on storm water utilities (APWA, 1991).

In 1989, MDE facilitated a comprehensive study of financing storm water in Baltimore County, Maryland. The framework of the study included the participation of a committee of interested parties convened by the county's Director of the Department of Environmental Protection and Resource Management. MDE produced a final report entitled *Financing Stormwater Controls in Baltimore County* (Lindsey, 1990) that documented the committee's recommendation to pursue a storm water utility approach. Soon after the completion of the Baltimore County study, an election resulted in a change of administrations. Support for the storm water utility dissipated with the departure of the previous administration.

Throughout the early period of its involvement in providing technical assistance, MDE staff made contacts with numerous county and municipal storm water managers. MDE staff made presentations and distributed briefing materials and a brochure based on excerpts from the 1988 studies. These contacts lead the storm water management staff of Montgomery County to undertake an extensive, independent effort to pursue a storm water utility (they are also considering an ad valorem tax). In addition, a citizen task force, appointed by the Mayor of the City of Rockville in Montgomery County, assessed storm water management in general and endorsed the pursuit of a storm water utility (Watson et al., 1992). The current political and economic climate has slowed these efforts; however, local staff voice confidence in their eventual success.

The state has devised an additional avenue for providing technical assistance, termed a preliminary investigation. This entails a review of the jurisdiction's current expenditures and future storm water financing needs with an eye toward the viability of introducing a storm water utility. A preliminary investigation can be conducted with or without the direct participation of the jurisdiction. If the jurisdiction does not actively participate, the results can be transmitted to interested parties to serve as a framework for discussion. These resulting documents often represent the only comprehensive estimate of the storm water management program's financial status. Participating counties have included Carroll, Cecil, Charles, and Harford Counties. Preliminary investigations have provided a forum for discussing the merits of storm water utilities and the resulting reports provide local staff with technical documentation that can serve as a starting point for future consideration of implementing a storm water utility.

In 1991, MDE developed an estimate of the revenue generating potential of each county (George, 1991). This report estimated the annual revenue potential of the statewide implementation of storm water utilities to be from $64 to $72 million depending on the fee structure. These estimates were of value in the successful introduction of enabling state legislation in

1992 that gives local jurisdictions explicit authority to start a storm water utility. Although implicit authority had been written into the Maryland's 1982 Storm water Management Act, local jurisdictions were reluctant to be the first to test that authority.

Currently, MDE is compiling case studies of how existing storm water utilities financed their start up costs, which can be a barrier to implementation. In addition, MDE is developing several slide show modules that can be mixed and matched for audiences of varying familiarity with the concepts of storm water utilities. These two projects represent a new phase in Maryland's technical assistance efforts consistent with jurisdictions moving closer to implementation.

The common themes of the efforts made by MDE have been the transfer of technical knowledge to local storm water management staff and the removal of various legal and financial impediments. MDE does not wish to engage in the details of implementing a jurisdiction's storm water utility. This should be performed by the counties with contracted assistance from an experienced consulting firm. The state's role is to get the process moving and to apply the necessary pressures through the review process to affirm that storm water management remains a high priority.

Concluding Observations

Maryland State Law is limited to controlling storm water management for *new* development. The federal Clean Water Act's National Pollutant Discharge Elimination System (NPDES) for municipal storm sewers expands the responsibility of local jurisdictions to also include *previously* developed land. Half of Maryland's counties are obligated to comply with new NPDES permits. Furthermore, the associated federal regulations require local financial responsibility as a term of compliance. Because these new regulations are associated with the federal Clean Water Act, their enforcement may be effected through third party law suits.

Public financing is an inherently political undertaking. Jurisdictions with pro-development administrations that use general funds as the primary revenue source for their storm water management programs almost invariably have weak programs. These jurisdictions are also unlikely candidates for the implementation of storm water utilities due to the orientation of their political leadership. As such, these jurisdictions may be exposing themselves to costly legal battles, if not fines, for failure to satisfy the financing requirements of NPDES regulations for municipal storm sewer systems.

Other jurisdictions that are open to the idea of developing dedicated financing mechanisms still face the political aspects of public financing. Until an understanding about the need for storm water financing is reached with vocal public interests, even benevolent public officials will be wary of endorsing a new tax or fee. States in this situation can provide support in the form of educational material for the public and technical briefing material for program staff and decision makers. As was demonstrated with the policy reversal in Baltimore County, political factors make the implementation of a storm water utility an uncertain endeavor.

Providing state-level legal authority is a key step that state agencies can take to pave the way for local storm water utilities. A valuable element of such legislation is the provision for itemizing the utility charge on the county property tax bill. While some counties may elect to use a separate billing system, such systems can be prohibitively expensive to develop. It is also advisable for the state law to impart the same penalties for failure to pay the utility fee as for taxes. This will help ensure that fee collection is enforceable.

MDE advises that a separate storm water utility ordinance be enacted, rather than combining it with the ordinance that authorizes the storm water management program (USEPA, 1992). This legislative structure will help insulate the storm water management program ordinance from malevolent amendments if the storm water utility ordinance requires amendments and vice versa.

For the past 6 years, Maryland has been engaged in efforts to influence local jurisdictions to institute dedicated funding for its storm water programs. Although this effort has not yet resulted in the implementation of a storm water utility in Maryland, states in a similar situation should not be discouraged. States can play an essential role in creating a fertile institutional environment for the local jurisdictions. In the end, behind each successful storm water utility is a small

cadre of well-informed, motivated local individuals. To the degree that state staff responsible for storm water management can identify and support these individuals, they should do so.

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Funding the Implementation of the Buzzards Bay CCMP: Searching for a New Approach

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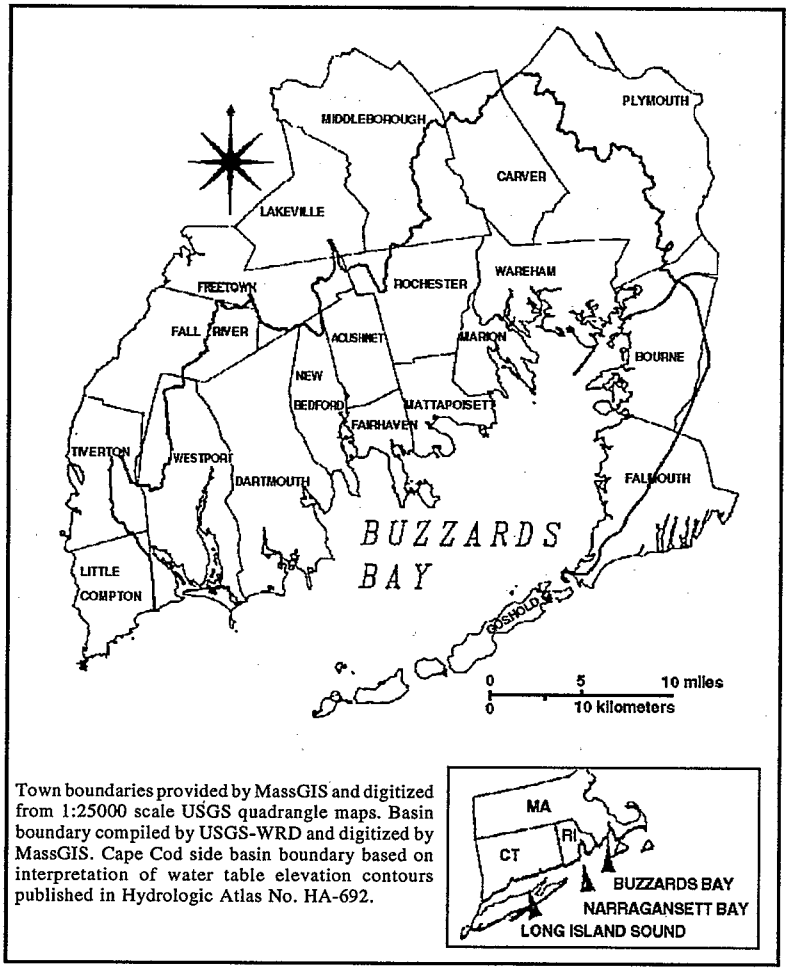
The Buzzards Bay Comprehensive Conservation and Management Plan (CCMP) is the result of 5 years of study and consultation among scientists, citizens, and all levels of government, along with pilot implementation projects conducted under the direction of the Buzzards Bay Project, part of the U.S. Environmental Protection Agency's (EPA) National Estuary Program (NEP). One of the products of the study is a set of 11 Action Plans, defining specific implementation objectives and methods deemed necessary to prevent increased degradation of Buzzards Bay (Figure 1) and to begin the remediation of existing problems. Because the Water Quality Act of 1987, which created the NEP, has no authorization for funding implementation and because federal spending is decreasing as a percent of total governmental spending on environmental quality (Figure 2), an essential part of the Buzzards Bay CCMP is a financial plan.

This financial plan includes a series of suggestions for funding sources. The litany of typical actions—bonding, taxation, fees, grants, etc.—is efficiently laid out.[1] In general, however, review of these various options has not generated much enthusiasm or optimism among local governments given the current status of government funding in Massachusetts, the decidedly unhappy mood of the public, and the large sums involved. This is not a good time for a "business-as-usual" governmental funding approach to meet the multi-million dollar need (Figure 3 and Table 1).



Town boundaries provided by MassGIS and digitized from 1:25000 scale USGS quadrangle maps. Basin boundary compiled by USGS-WRD and digitized by MassGIS. Cape Cod side basin boundary based on interpretation of water table elevation contours published in Hydrologic Atlas No. HA-692.

Figure 1. Buzzards Bay and its drainage basin.

[1] See Buzzards Bay Project: Buzzards Bay Comprehensive Conservation and Management Plan, Volume II, August 1991.

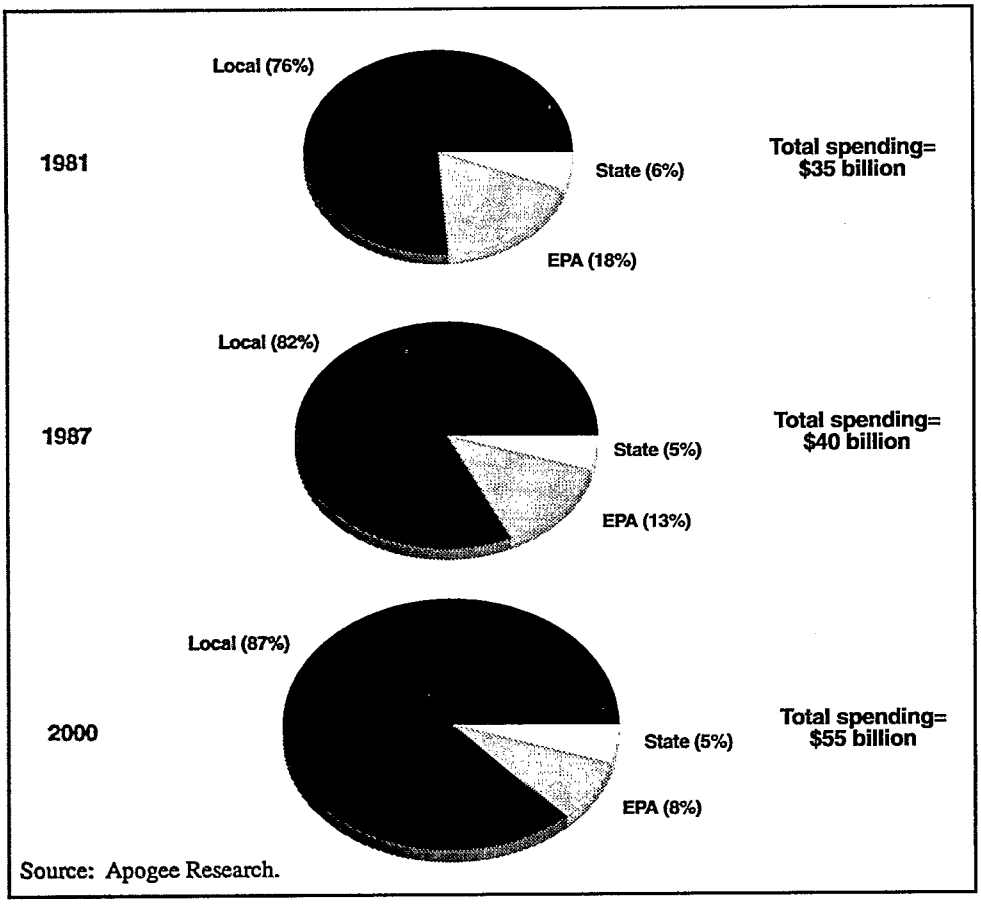


Figure 2. Environmental outlays by level of government.

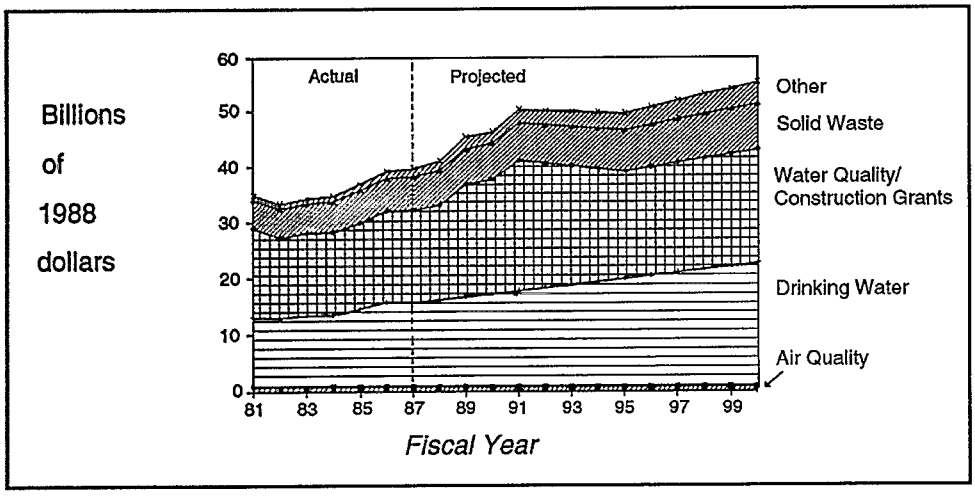


Figure 3. Expenditures on environmental quality by all levels of government.

Something new is required: a method not only creating a source for the necessary investment, but also influencing individual decisions through economic incentives instead of regulations.

Anyone who has spent time as a regulator at the local level in recent years knows of the growing backlash on the part of voting citizens upset about their out-of-pocket costs and that businesses complain about reduced productivity and competitiveness. It is beginning to threaten much of the progress made in environmental protection. Increasingly successful political action against local officials who support the implementation of national standards expressed in such legislation as the Clean Air and Clean Water Acts, coupled with the economic recovery that will soon stimulate development activity across the country—development largely regulated by local officials—portends ominously for the health and safety of environmental resources in general and watershed resources in particular given the major role local government expenditure must play (Figure 4). Establishing strict standards, relying on regulatory activity and legal enforcement, has brought us a long way, but if we are to avoid serious reversals, much less continue to improve our ability to protect and enhance valuable environmental resources, we must move beyond "command and control" techniques and try to find other ways to influence the day-to-day economic choices made by individuals. What is "good" for people and what is "best" for the planet will not persuade individuals to change their behavior. Giving them cash-based incentives will. We must make the marketplace work for us by entering into its transactions rather than attempting to restructure them from without.

One such approach is the use of betterments—fees assessed against property owners in the form of charges on their regular property tax bills. In Massachusetts, betterments are typically used for services provided only to a specific portion of the property owners within the municipality,[2] such as sewer and water line extensions, sidewalk repairs, etc. (Massachusetts General Laws; MGL Chapter 80, Sections 1-17). In some communities, bylaws have been adopted to further allow their use in repairing private ways. It is this last use of betterments for certain improvements to private property that has suggested to us some possible innovations in municipal cash management, marketing of municipal bonds, and state and federal income tax policy, as a way to drive private investment in the various actions recommended in the Buzzards Bay CCMP.

We propose a combination of tax incentives with modifications in public and private financial practices designed to drive private investment in projects beneficial to watershed management. Many worthy goals including septic system repairs and upgrades, improved storm water management and treatment, toxic pollution abatement, toxic use reduction, habitat and wetland protection, and expansion of open space, can be promoted rather than coerced if we can create new investment vehicles. Potential investment will be significant and local and regional economic stimulation will be an important result. One such vehicle could possibly be a Betterment-Backed Security (BBS), similar to the Mortgage-Backed Security traded every day. BBSs could be further supplemented by Environmental Revenue Bonds (ERBs), which are similar to Industrial Revenue Bonds. Gifts of land or development rights that protect habitat or wetlands or serve other valid public purposes could be deductible at rates greater than their market value, creating transferable tax credits. And, finally, changing the actual manner in which government manages its cash could significantly lower transaction costs through staff reductions, increasing cash available, and/or reducing taxes.

Table 1. Preliminary estimate of financial costs to implement management actions in Buzzards Bay

	5-year Total ($)	Annual ($)
Storm water remediation (400 discharges, $25,000 ea.)	10,000,000	2,000,000
Boat pump-out + waste collection (15 facilities, $25,000 ea.)	375,000	75,000
Land-use planning, N management (15 embayments, $30,000 ea.)	450,000	90,000
Oil spill containment equipment (municipalities and regional aid)	100,000	20,000
Resource mapping, harbor planning (7 municipalities, $60,000 ea.)	420,000	84,000
Municipal grants (for innov. demonstration projects)	1,500,000	300,000
Special assessments (monitoring, special research investigations)	3,000,000	600,000
Technical assistance to municipalities	2,250,000	450,000
Education, outreach, citizen programs	750,000	150,000
Toxic source reduction	750,000	150,000
Agricultural NPS projects and BMPs	500,000	100,000
Projects to restore and protect habitat	500,000	100,000
Project administration and support	750,000	150,000
TOTAL	21,345,000	4,259,000

Other issues not addressed with NEP funding:
Remediation activities in New Bedford (sewage treatment facility upgrade, CSO remediation, and Superfund PCB cleanup) will cost $200 million-$300 million.

To begin with, let us look at the idea of BBSs. Betterments are charges levied by government, usually in the form of specific tax billings, on property that has received a benefit not universally shared throughout the municipality. Once assessed, betterments are senior liens to all but federal and state taxes; they are collectable by the taxing jurisdiction in exactly the same way as property taxes. A property owner needs no credit qualification for a betterment; succeeding owners are bound to repay them without any legal procedure other than that which transfers title; and the funds expended are borrowed at the public cost of money, often far less than that of loans available on the private market. Finally, unlike normal municipal bonds which are issued on the "full faith and credit" of the municipality, and which require the annual raising

[2] We will use "municipal" throughout this paper as synonymous with any appropriate governmental entity.

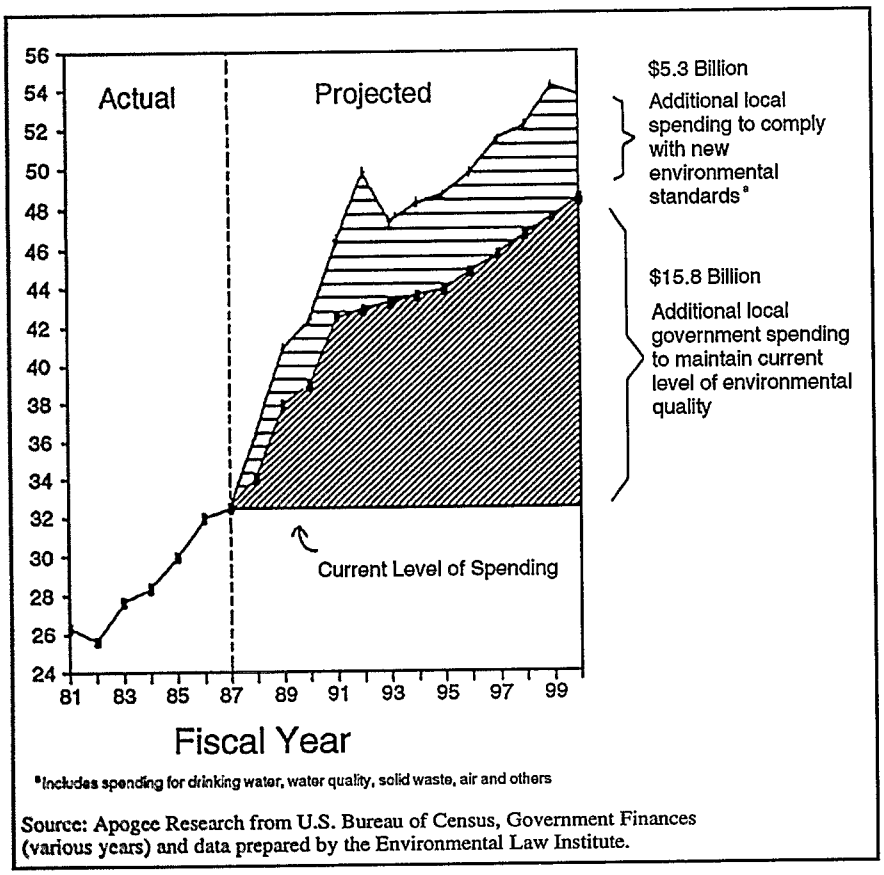


Figure 4. Local government expenditures on environmental quality.

through taxation of the appropriation for repayment, betterment borrowing is repaid through transfers from a special revolving fund within the municipal treasury that has been set up to receive the betterment payments made by property owners. Repayment of the notes is secured by the tax collector's capacity to seize property for nonpayment of betterment charges and, being an administrative rather than political process, represents less risk and is the same for each municipality, regardless of bond rating, and for each betterment regardless of the size or nature of the betterment. As the first chart below indicates, other things being equal, from a property owner's point of view the betterment offers a less expensive and more accessible means of funding for necessary improvements.

There are also significant benefits from the point of view of the institution lending the money. The cost of closing each loan is significantly reduced because no credit check is necessary. The actual processing of each betterment, record keeping, and if necessary, enforced collection are the responsibility of the municipality administering the betterments. Collection is guaranteed by a legally binding and largely automatic administrative procedure, making the loan one of very low risk with only state or federal tax liens senior to it.

Thus a bank, or other lender, would have significantly lower processing costs and less risk when loaning against betterments as compared with typical mortgages or home improvement loans. The comparison of betterments to normal municipal bonds is somewhat less straightforward but also includes significant savings and modest risk reduction. (See second chart.) Because the payment of principal and interest is guaranteed by the administrative process of collecting fees and the legal authority to take property for failure to pay and not by the annual tax levy, there is almost no risk of default driven by political issues or financial difficulties that may confront the municipality. All that is needed is an efficient recording and collecting procedure, easily supplied at low cost to any tax collector's office in the form of a small computer and simple program. Many tax collectors' offices already have the necessary capacity. The added cost of betterment fee administration should be small and can be borne by each project. Essentially, all the processing is done by the municipality; the bank only has to place the loan with investors. And, as the cost of processing a betterment loan to the bank is less than a municipal bond offering, with the risk of default or late payment also reduced, the interest rate charged to the borrower should be lower.

This brings us to another interesting characteristic of BBSs: each individual betterment lien, whether on a private residence, a condo complex, an office building or factory, is, for all intents and purposes, identical in quality from the loaning (investing) institution's point of view. The security of each loan is not the property owner's capacity to repay, but the municipality's capacity to seize and sell property for nonpayment. A capacity that is legally secure, administrative in nature, and whose standard of performance (i.e., how much of a break can the tax collector give

any given betterment payer in trouble) can be defined by binding contract. Further, unlike a municipal bond, which is guaranteed by the issuing municipality's "full faith & credit" and is subject to a bond rating, every betterment within the state is exactly the same in terms of payment guarantees and risk. Therefore, lending institutions can pool betterments, affording the same low costs to each betterment payer, regardless of size, type, or location, and offer the large institutional investor substantial blocks of very high quality, double tax-exempt paper. In Massachusetts, you could sell such paper all day long!

Comparison of Betterment vs. Mortgage/Loan

	Betterment	Mortgage/Loan
1. Interest Rate (Est.)	4.5%-6.5%	7%- Up
2. Term	5 - 20 Years	0 - 30 Years
3. Owner Credit-worthy	Not Necessary	Yes
4. Up-front Fees	No	Usually
5. Lien Transferable	Yes	No

	Betterment	Municipal Bond	Mortgage/Loan
1. Security	Property	Full Faith & Credit	Property
2. Default =	Seizure & Sale	Court Action	Foreclosure & Sale
3. Repayment	Transfer	Appropriation	Billing
4. Inv. Quality	Identical	Issuer-Dependent	Borrower-Dependent

In an effort to take advantage of the potential benefits offered by betterments, the Massachusetts Association of Health Boards (MAHB) and the Buzzards Bay Action Committee (BBAC) have drafted and filed legislation known as the "Betterment Bill." This bill expands the traditional use of betterments to include septic system repairs and lead paint removal. It links these betterments with the substantial authority local boards of health have in Massachusetts to compel the abatement of a threat to the public health and safety (Massachusetts General Laws; MGL Chapter 111, Sections 31, 122-154.). It also allows for the property owner to petition the board of health for the use of betterments for septic system and lead-paint projects. We expect its passage this session and hope to begin putting it to use in Fiscal Year 1994 municipal budgets. Initially, it will involve traditional financing as the BBAC must further explore the possibility of putting BBSs to work with various banks. Discussions have already begun with a large regional bank, but it is unclear at this time whether further legislation will be needed.

Typically, municipalities would be able to take any of three approaches:

1. Individual property owners get projects permitted, bid, and qualified, then sign up for an annual betterment borrowing. As part of its annual budget process, the municipality authorizes the betterments and the necessary borrowings. Upon obtaining the funds, the projects are authorized and go through the normal inspection process, the various contractors are paid at the agreed price upon successful completion of work, and collection of betterment charges and payment of note begins, timed so that collections precede payments.
2. The municipality invites property owners to submit projects. After permitting and qualification procedures, the municipality puts projects out to bid as a group, or in groups, whichever is appropriate. Bids are awarded and upon obtaining funds the projects go through the normal inspection process; the various contractors are paid at the agreed price upon successful completion of work; and collection of betterment charges and payment of note begins, timed so that collections precede payments.
3. In order to accommodate emergencies and special circumstances, an annual budget might include a borrowing authorization up to a certain limit for projects meeting specifically defined criteria. The authorizing board or commission might pool projects, or do them one at a time, with the treasurer borrowing in anticipation of revenue. The projects could be then rolled into a larger betterment borrowing in the next annual budget.

Working with the member municipalities of the BBAC, we expect to quickly

establish common procedures for the use of betterments. An $8,500 grant has recently been given to the MAHB to work with local boards of health to standardize local health regulations to begin this effort. With such procedures in place, we will move to expand the application of the Act, offering amendments to include point and nonpoint source pollution reduction, sewer pretreatment, fuel storage tank management, and toxic and hazardous material clean up. Given the broad powers of boards of health in Massachusetts, linking betterments and the management objectives of the Buzzards Bay CCMP through them provides substantial opportunity to encourage voluntary compliance with existing law and regulation because of the reduction of costs to the property owner. Property owners often conceal violations because of legitimate concerns about the cost of abatement. Many times a board of health, faced with property owners unable or unwilling to pay for proper abatement, is itself unwilling to go through the process for compelling compliance and either ignores the problem or allows a substandard abatement. Either case, while possibly defensible in isolation, adds to the future cost of full CCMP implementation as some further, and largely duplicative, action will eventually be required.

Along with these efforts, we will continue our discussion with area banks in an effort to pool betterment borrowings from all the BBAC municipalities. This substantial borrowing should, we hope, lead to significant reductions in costs, as discussed above, and lead to the development of BBSs. We have already discussed with a regional bank the possibility of creating an environmental mutual fund that would attract investors with both a high-quality Massachusetts tax-exempt investment and its environmentally beneficial nature.

Also, we will explore the use of board of health regulations and/or municipal bylaws, modeled on the private way repair bylaws mentioned above, to allow for remediation of septic system problems on a neighborhood basis. One of the important aspects of the private ways bylaw is its ability to compel the participation of all residents whose property has frontage on a private way if a certain percentage of those residents vote to improve that way through the bylaw's betterment procedure. We are proposing a similar mechanism be crafted that establishes standards for defining a neighborhood that has septic system problems significant enough to warrant a neighborhood-wide remedial action instead of a property-by-property approach.

Typically, a board of health would investigate problems in a given area. Using these standards would ascertain the need for a neighborhood remediation. After going through a proper hearing procedure, the Board could order the remediation undertaken. It would then oversee the design, review, and construction bid process; award contracts; establish betterments; and seek the appropriate borrowing authorization. With the other mechanisms discussed above in place, the process should result in a superior remedial effort at as low a cost to the property owner as is reasonably possible. Such lowering of costs will obviously expand resources available, encourage cooperation, and reduce the expenses related to case-by-case enforcement. It will also help change the relationship the board of health has with property owners who have problems from an adversarial relationship to one of cooperation.

Beyond these actions, municipalities, most likely through their boards of health, can individually or in some regional association further reduce the costs to property owners of septic system maintenance and repair by establishing On-site Management Districts (OSMD) that take over these responsibilities.[3] Preliminary analysis of an OSMD in the Town of Marion indicates that if such districts are formed, and the upgrading and repair of septic systems is organized in an orderly and rational manner, reflecting both environmental and economic considerations, that remarkable savings can be realized. By charging septic system owners annual fees based on water usage or septic system type and using betterments to upgrade and repair systems, it appears OSMD annual fees would be less than those of sewer users and that the one-time betterment charge would be about 80 percent of actual cost. In effect, an OSMD would make Marion septic systems behave, from the property owners' point of view, exactly like a sewer. Pay an annual fee and a one-time betterment charge for an up-grade to current standards, and the OSMD looks after your septic system

[3] Similarly, when the Betterment Act is amended to include storm water drainage and treatment, Drainage Utilities can be set up, which will operate in much the same manner as OSMDs.

forever, including future repairs or upgrades. It is hard to over estimate how much easier a board of health's work would be with the establishment of a successful OSMD. And, at least in Marion's case, the increase in property values through the resolution of septic system problems—at least 2/3 of Marion's 1600 septic systems need attention—coupled with the injection of cash into the local economy through the upgrade contracts—estimated at over $5,000,000 within seven years—offer substantial economic as well as public health and environmental benefits.[4]

Assuming we can accomplish all of the above, there are further measures that federal and state governments should review. In any given CCMP or other resource management plan, there will be particularly important or especially difficult tasks. In an effort to most efficiently stimulate investment in these tasks, consideration should be given to making some or all of the capital investment made by a property owner under an appropriately qualified program tax deductible. Here we propose the use of Environmental Revenue Bonds (ERB), modeled after Industrial Revenue Bonds (IRB) that have been used as a vehicle for economic development for so many years. If you would consider the betterment-driven process we have discussed in detail above, imagine the further stimulus to property owners to participate if they knew that some part of the principal portion of their betterment was tax deductible. The authorization of ERBs could replace some of the block grant programs, representing a much more efficient use of federal resources, a tax expenditure being far less costly to administer than the collection of tax revenues with the subsequent high cost of redistribution through heavily administered grant programs. Each project would carry the cost of its administration and oversight, obviating the need for some of the permanent staff doing this work in federal and state agencies.

Even in projects that did not qualify for ERBs, similar cost savings can be realized by replacing grant programs with direct revenue sharing. Again, qualified programs that normally would receive some federal or state match through existing grant programs would also be required to cover the costs of their administration and oversight, and the matching funds could be paid directly from the federal or state treasury without the need for disbursement through their bureaucracies. This again reduces the need for permanent staff in oversight agencies, makes each project justify and bear its own administrative costs, and would be a much more efficient use of the taxpayer dollars.

In order to encourage the up-front research and planning necessary to develop projects, revolving fund programs could be used. Initially set up with state or federal grants, these grants could slowly be repaid through a surcharge on projects. When an adequate revolving fund level for any given area or purpose has been achieved with all federal and state money repaid, the surcharge can be removed and future projects simply reimburse the fund for borrowings and administrative costs.

Finally, there is the possibility of establishing transferable tax credits to encourage gifts of land, establishment of various types of easements, and the further stimulation of investment. One of the driving forces behind development is the way the federal government taxes land in estates. If an estate has $100,000 worth of land, and is in the federal 50 percent tax bracket, it must also have $100,000 in cash to pay the necessary taxes on both land and cash. Otherwise, the land must be sold to pay its own tax burden. It would seem reasonable, as land development often threatens valuable environmental resources and creates adverse impacts,[5] to change the federal inheritance tax code to allow gifts and easements that enhance and/or protect some identifiable public good, to be deductible at more than 100 percent of market value. This would slow development in sensitive areas, and certainly encourage gifts of land!

The same logic could be applied to investment profits. Transferable tax credits could be allowed financial institutions and individuals for investments in qualified projects, for example, certain classes of ERBs. As above, these credits represent a tax expenditure that could be used to off-set

[4] A multiplier factor of 6 is often used to compute the added value to the local economy of each dollar spent on such projects.

[5] It should be noted that single-family home development almost always pushes up local property tax rates through increased demand for services. There are more than just environmental reasons to limit subdivision of land!

grant programs in an appropriate manner, further stimulating private investment and reducing government's size and cost.

In summary, while all of the above is largely only an intellectual exercise, the mechanisms discussed could certainly be refined and established. This could go a long way in undoing the unfortunate expansion of central government, which has caused atrophy of ability and will at the local level. While federal and state government must carry on programs of research and evaluation and must continue to establish and sustain the broad national values expressed in legislation such as the Clean Air and Clean Water Acts, the actual work of developing remedial programs for environmental problems must become increasingly problem and site specific. Such a new approach would provide flexibility and improve cooperation between levels of government and between government and citizens; it would stimulate private investment and its related growth in economic activity and eventually allow for reduction in governmental overheads having achieved more efficient use of the taxpayer dollars. This efficiency mainly arrived at by not collecting dollars as taxes at all, but by having dollars spent directly in the support of clearly defined public policy objectives by private parties.

The "Local Loan Fund"—A Solution to Many Watershed Pollution Control Problems

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Background and Rationale

Malfunctioning septic tank systems and improper agricultural practices are major nonpoint pollution sources to watersheds of Washington State and many other areas of the country. In Washington State there are about 600,000 on-site septic tank systems that serve approximately 25 percent of the state's population. Largely because of substandard soil conditions, approximately 10-15 percent of these systems do not function properly. Therefore, at least 60,000 septic tanks are presently discharging inadequately treated sewage to the surface water and ground water of our watersheds. Likewise, much of the 31 million pounds of manure produced each day by the state's dairy herds ends up in our state's waters.

Unfortunately, private property owners do not always have the money needed to correct these costly problems. For example, engineered drainfield designs, such as "mound systems," which are often the only alternative when standard gravity drainfields fail, frequently cost $8,000 to $12,000 to install. Likewise, for farm operators, costs often exceed $10,000 to provide adequate manure lagoons, install equipment that limits storm water runoff, and implement other farm plan measures.

No governmental program or private bank was available to rehabilitate septic systems, and there was very limited support for installing agricultural best management practices (BMPs).

A Possible Solution?

In response to these problems, nine of Washington State's county governments and two conservation districts have developed local loan funds through the Washington State Revolving Fund (SRF) administered by the State Department of Ecology. These funds provide low interest loans to homeowners to repair or replace failed septic tank systems and to farm operators to implement agricultural best management practices. Local governments use the SRF to initiate their programs. Even though the concept is less than 3 years old, at least 60 loans have already been issued in the state, and the water quality problems have been corrected. Furthermore, many more such loans are pending approval.

How Does the SRF Work?

To initiate the SRF programs in all 50 states, Congress provided that grants be issued to the states from the U.S. Environmental Protection Agency. Although grant funds are subject to congressional appropriation, Washington State has received between $30 million and $40 million each year since 1989 to "seed" its SRF program. Other states receive proportionally more or less depending on population and documented water pollution control needs. States must add $1.00 of state money to every $4.00 of federal money received.

Through legally binding agreements, states issue loans to local governments for water pollution control projects. Most loans

are issued for multimillion-dollar sewage treatment projects, but states have much flexibility to develop innovative approaches to solving water pollution control problems such as the local loan strategy.

Under the local loan fund approach, the local government determines how many loans it believes it can make during the project period and estimates the total cost of the loans. The local government is issued an SRF loan for this amount from the state. Repayments to the local loan funds from participating residents and county taxes are used to repay the often interest-free SRF loan. Local governments must begin repaying the loan to the state within 1 year of the end of the project period. Repayments to the SRF would usually begin about 3 to 4 years after the loan was issued. Local governments are encouraged to require that repayments to their funds begin as quickly as possible so that a repayment account is established.

Federal seed grants are presently slated to be ended next year with repayments to loans being the sole source of funds, but because the SRF program has been so successful, Congress is now considering extending the federal seed phase through 1997. State SRF pools could be substantially bigger and easier to maintain "in perpetuity" as the 1987 amendments to the Clean Water Act mandated. However, most states are now issuing some loans from the repayments on earlier loans. Therefore, some money may already be available from state revolving funds for high priority water pollution control projects.

Are Local Loan Funds a "High Priority"?

The SRF development staff in Washington State recognized that nonpoint source projects could not fairly be compared to municipal sewage treatment plants in terms of water quality benefits. Therefore, by state regulation, 10 percent of the fund was reserved each year for nonpoint water pollution control projects. It is from this reserve that loans to local governments for septic system repair and agricultural BMPs are issued. This provision for nonpoint source projects was in concert with Congressional intent to transition from federal grants to state issued loans for sewage and storm water treatment *and* to finance nonpoint source projects.

Because loans from the SRF for local loan funds are usually for between $100,000 and $300,000 over project completion periods of 2 to 3 years; a relatively small percentage of the money available in the SRF goes to such projects. During the first 4 years of the SRF, much of each year's reserve was used to help finance point source projects, such as sewage treatment plant upgrades and combined sewer overflow reduction projects. Last year approximately 6 percent of the SRF funds available were offered to local loan fund projects. The great majority of the money is used to help finance more traditional larger scale point source projects. Therefore, there have been few, if any, objections to the concept of using the SRF program to finance nonpoint source projects.

Local Loan Fund Program Provisions

Under the local loan fund concept, local governments have a great deal of flexibility to set the terms of the loans to private individuals in order to address special situations (for example, low-income provisions) as long as they continue to keep water quality improvement in the forefront.

All local programs protect their loans by receiving liens on property to guarantee that if the property is sold or inherited, the loan is repaid at that time. Several programs rely on local banks to review applications, loan agreements, issue reminder notices, etc. At least some banks have volunteered to provide these services at cost, as a public service to the communities. This strategy relieves county staffs that may not be completely comfortable with detailed financial and legal documents and also may help stabilize the seasonal workload peaks and valleys for loan processing and construction activities.

One of the conservation districts, which issued 9 loans during the first year of service and received another 30 applications, has developed an innovative collection approach. Because all loans issued are for dairy waste BMPs, the local milk processing plant deducts the monthly loan payments from checks it issues to farmers for milk production. The milk processor then sends these repayments directly to the conservation district.

Matters That May Surface

Any new concept has issues that must be addressed. The staff of the state's Attorney General should be made aware of the approach as it is developed. County attorneys must also approve the loans to the county. The major public benefits of clean public waterways and public health are factors that may need to be understood as they consider the strategy.

One of the most important aspects of the program is the need for counties or other financially sound taxing authorities to guarantee repayment of the SRF loan. This provision is critical because it distances the state's SRF from any possible defaults on loans issued to private individuals. It also fulfills the Federal Clean Water Act requirement that SRF loans be issued only if there is a "dedicated source of repayment."

Conclusion

Through local loan funds, local governments can prioritize how funds are dispersed to achieve the greatest overall water quality improvement and solve their most critical problems. For example, a county may opt to target specific watershed(s). As the concept is adaptable, local governments may help to solve many of their watershed problems through the local loan fund concept.

Public bodies throughout Washington State are encouraged to use financial assistance available from the Department of Ecology to establish similar programs. Cooperative efforts between Washington State's local governments and the State Department of Ecology could be used in other states as an example for other water quality and public health agencies to use as they address their own critical watershed management problems.

Using a Geographic Information System as a Targeting Tool for Pennsylvania's Chesapeake Bay Program

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History of Pennsylvania's Chesapeake Bay Program

1983 Chesapeake Bay Agreement

In 1983, the Governors of the States of Virginia, Maryland, and Pennsylvania, and the Mayor of Washington, DC, signed an agreement to work together with the U.S. Environmental Protection Agency (EPA) to reduce nutrients (nitrogen and phosphorus) to the Chesapeake Bay. This agreement was written in response to a study recently completed by EPA which documented the severe decline of the Chesapeake Bay due to an excess of nitrogen and phosphorus.

Pennsylvania's Program Development

In response to the 1983 Agreement, the Commonwealth of Pennsylvania, Department of Environmental Resources (DER), Bureau of Land and Water Conservation (BLWC), developed a program to reduce nutrients entering the bay from the Susquehanna River and the state's portion of the Potomac River. An integral part of the program involved the cost sharing of best management practices designed to reduce nutrients from agricultural sources. Currently, 80 percent or up to $30,000 per landowner is given to farmers to help remediate their nutrient management problems.

It was recognized that a method of targeting or prioritizing watersheds would be needed to ensure that the limited cost share monies would be spent where the most progress could be made. The first list of priority watersheds came from the "208 Study." This was a study conducted in the late 1970s by the Department of Environmental Resources in response to section 208 of the Clean Water Act. This study identified high-, medium- and low-priority watersheds within the state according to their potential to create agricultural pollution. After an intensive, detailed watershed assessment was completed by the County Conservation Districts, farmers located within these priority watersheds were considered eligible to receive financial assistance for the installation of best management practices. The priority watershed assessments were completed in four phases between 1985 and 1990.

1987 Chesapeake Bay Agreement

In 1987, the Governors of Virginia, Pennsylvania, and Maryland, the Mayor of Washington, DC, the Administrator of EPA, and the Chairman of the Chesapeake Bay Commission signed a second agreement. The most important component of this agreement required the signatories to reduce the amount of controllable nutrients to Chesapeake Bay by 40 percent by the year 2000.

The states had to write a strategy as to how they would each reach their respective

reduction targets by the year 2000. The initial prioritization scheme developed from the "208 Study" was continued, since it was imperative to target limited resources in order to achieve the goal by the year 2000.

The Environmental Resources Research Institute (ERRI) Project

By 1990, the four phases of watershed assessments were completed, and farmers within these watersheds had begun to receive cost share monies to remediate their nutrient problems. All the high and medium priority watersheds identified in the "208 Study" were made a part of the program. During this time, several questions were raised—Where do we go from here? Are the limited resources available to the program being spent where they can do the most good?

In order to answer these questions, a project was begun by BLWC, in cooperation with Pennsylvania State University's ERRI. This project was designed to use a Geographic Information System (GIS) to compute an Agricultural Pollution Potential Index for the 104 watersheds identified in the State Water Plan.

Data Collected

Data were collected and input into the system using a scale of 1:250,000 at a 100-meter square grid. Over 250 million bytes of data were developed and combined. Data were collected to develop the following seven layers (Petersen et al., 1991, p. 2):

1. *Watershed boundaries.* The State Water Plan Boundaries for the state's 104 watersheds were digitized by ERRI.
2. *Land Use.* Data from the U.S. Geological Survey (USGS) Land Use Data Analysis (LUDA) program were used for the years 1972 through 1978.
3. *Animal Density.* The 1987 U.S. Agricultural Census data were used. Animal populations were obtained by ZIP code and combined with the agricultural land uses to identify animal density and to compute animal loading (lb/acre).
4. *Topography.* These data were developed from the USGS Digital Elevation data. Percent slope was calculated using these data.
5. *Soils.* The Soil Conservation Service (SCS) State Soil Geographic Data Base (STATSGO) was used.
6. *Precipitation.* These data are a combination of data derived from climatological station summaries by the National Climatic Data Center in North Carolina. This data layer was developed in cooperation with Zedx, Inc.
7. *Rainfall-Runoff Factor.* Also developed by Zedx, Inc, this layer consists of average monthly erosion indexes using average annual and regional monthly profiles. This factor is an integral part of the Universal Soil Loss Equation developed by SCS to determine the amount of sediment generated from erosion.

Development of Pollution Indexes

Using the data layers described above, ERRI developed four pollution indexes for agricultural pollution. These four indexes can then be combined in any fashion, and weighted to develop a final agricultural pollution potential index. The four indexes are:

1. *Runoff.* This index was developed by combining the Land Use, Soils, and Precipitation data layers. The result is an index for each watershed in inches of runoff (Petersen et al., 1991, p. 8).
2. *Chemical Use.* This index was developed using a ranking system of chemical use, depending on the land use (Petersen et al., 1991, Table 5).
3. *Sediment Production.* This index was developed using the SCS Universal Soil Loss Equation. The different layers were combined to develop the different factors used in the equation. The result is expressed in tons/acre/yr (Petersen et al., 1991, Tables 1 and 2).
4. *Animal Loading.* This index was developed by combining the animal density data by ZIP code and overlaying the land use in each watershed. By converting the animal populations to pounds of nitrogen and phosphorus generated, an index of pound nitrogen or phosphorus per acre of agricultural land was developed (Petersen et al., 1991, p. 9).

The final Agricultural Pollution Potential Index can be any combination of these four indexes. Petersen et al. developed this index two ways. They computed an index for each watershed by using the entire acreage of the watershed, and an index for each watershed by using only the agricultural acreage in each watershed. These four indexes were also combined using an equal weighting, and a weighting of 30 percent for the Animal Loading, Sediment Production, and Runoff indexes, and a 10 percent weight for Chemical Use.

This project took 1.5 years to complete. Extensive assistance and cooperation with USGS, SCS, the Pennsylvania Department of Agriculture (PDA), and the Susquehanna River Basin Commission (SRBC) was used to enhance and develop this project. Using monitoring data for several watersheds obtained from SRBC, the ranking and indexing process was validated and verified. The monitoring data were used to develop an index and ranking of eight watersheds. The relative ranking in each of the four indexes, as well as the final agricultural pollution potential index, were compared for these eight watersheds. The relative rankings came out the same.

How Is This GIS Used by DER?

This project has been used in many ways by the Department. Agricultural Watershed Assessments conducted by the BLWC have been conducted statewide. The identification of priority watersheds for these assessments was done using the agricultural pollution potential index for watersheds developed with the Agricultural Land Only acreage. This system has also been used to help the state's Nonpoint Source Program (section 319 of the Clean Water Act) identify priority watersheds for comprehensive watershed remediation projects. The most valuable use of this system has been to identify priority watersheds for Pennsylvania's Chesapeake Bay Program.

Use by Pennsylvania's Chesapeake Bay Program

The first step taken by the BLWC was the development of a workgroup to determine how best to use this system for the Bay Program. Members of this workgroup included staff from the Chesapeake Bay Foundation (CBF), the SCS, and the BLWC. The workgroup combined the four indexes in various ways and came up with three different options for consideration by the State Conservation Commission. (The Commission is a group established by state law, chaired by the Secretary of the Department of Environmental Resources, to oversee and supervise all activities of the county conservation districts.)

The workgroup decided that the Sediment Production Index and the Animal Loading Index best reflected the emphasis of the program. The workgroup members felt that the Sediment Production Index gave an indication of where the best management practices used to control erosion should be implemented, and the Animal Loading Index gave an indication of where the most severe animal waste problems were. Based on estimated nutrient savings from best management practices tracked as part of the cost share program, it was determined that 80 percent of the nitrogen and phosphorus was saved through practices designed to handle animal waste problems, while 20 percent of the nutrient savings came from the implementation of practices designed to reduce erosion.

After consideration of several combinations and various weights, the three options developed for the Commission's consideration involved the combination of the Sediment Production Index, with a 20 percent weight, and the Animal Loading Index with a 80 percent weight. The difference between the options involved the method used to calculate the *norm* which was used to rank each watershed—the higher the *norm*, the higher the pollution potential index, and the higher the watershed is on the priority list. The *norm* was computed using the equation:

$$\frac{\text{Index Value - Mean}}{\text{Standard Deviation}}$$

The difference involved the calculation of the mean and standard deviation of the watershed indexes. The first option calculated a mean and a standard deviation using all 104 watersheds in the state. The second option calculated a mean and a standard deviation using only the 48 watersheds in the Chesapeake Bay drainage basin. The third option involved calculation of the mean and standard deviation without using the indexes for the three highest ranked watersheds. The workgroup felt that

the index and *norm* for these three watersheds was so much higher than the rest of the basin that the priority list developed had a bias which left little room for further development of the program. The Commission selected the third option. The list of priority watersheds is included in Table 1; the map of priority watersheds is Figure 1.

Referring to Figure 1, it can be seen that some of the watersheds identified in the "208 Study" are part of the new priority list and remained in the Chesapeake Bay Cost Share Program. Ten new watersheds were identified to be included into the program. Detailed watershed assessments of these ten watersheds will be completed by the County Conservation Districts by the end of 1993. The other watersheds shown in Figure 1 are watersheds which were part of the initial priority watershed list, but are no longer identified as a priority. It was the decision of the Commission at that time that these watersheds would be phased out over the next 2 to 3 years.

Plans for the Future

A GIS such as this is only as good as the data entered into the system. Provisions should be made to update and enhance a data base such as this as new data are obtained.

Revision of the Land Use Data

Current land use data were identified as data that would greatly improve the applicability of this system. EPA has developed 1990 land use/land cover data for the entire Chesapeake Bay drainage basin using its Environmental Monitoring and Assessment Program (EMAP). EPA has developed land cover/land use data at a scale of 1:100,000, using thematic mapping and satellite imagery to develop data on a 25- to 30-meter grid. This grid was then smoothed to a 100-meter grid.

The BLWC developed a contract with the EMAP lab in Las Vegas, which was developing this land use/land cover data for the Chesapeake Bay, to complete coverage of the rest of the State of Pennsylvania at the same time the data for the Chesapeake Bay drainage area was completed. Due to an audit of the EMAP lab, this project was terminated before the remaining area of Pennsylvania outside the Chesapeake Bay drainage area was completed.

Other options are now being explored by DER to develop these data at a scale of 1:100,000. These options include:

1. Cooperating with USGS to develop these data at an Andersen Level 2 Classification. This would follow the same procedure used to develop the original 1972-1978 data.
2. Requesting that Pennsylvania State University complete the data for the State of Pennsylvania, using the protocol developed by EMAP during the Chesapeake Bay Pilot Project.

It is planned that a decision will be made shortly so that this project can continue and the data can be completed by October 1994.

Once this data layer is obtained, the Agricultural Pollution Potential Index will be revised to reflect the changes in land use. The Chemical Use Index will be greatly enhanced by the use of this updated data. The idea of using the 1972-78 and the 1990 data to determine land use changes and trends is also being explored.

Revision of the Animal Loading Index

After the priority watersheds were identified for the Chesapeake Bay Program, several of the county conservation districts started investigating the accuracy of some of the data used. It was found that the Agricultural Census Data significantly underestimate the actual animal populations in some watersheds. This is due to the following reasons:

1. The original data were collected by ZIP code. It was found that in certain ZIP codes, only one producer existed. In order to protect the privacy of that one producer, no information concerning numbers of animals was provided to Pennsylvania State University. In the case of poultry, the differences are significant.
2. The address of the producer who filled out the form may be different than the actual location of the animal. This may result in the location of an animal or population of animals being located in the wrong watershed. It is estimated that this may generate as much as a 20 percent error in the calculations (John Blackledge, U.S. Agricultural Census Bureau, voice communication).

Table 1. Priority watersheds

ERRI Project -- Alternate Run 3 Option "C"

NOTE: Norms were calculated using only Bay Watersheds, minus the Top 3

Final Rank	Final Norm	Water-shed	Major Streams	Counties
*1	6.72814	7J	Conestoga River	Lancaster/Lebanon
*2	6.36558	7G	Chickies Creek	Lancaster/Lebanon/Dauphin
*3	4.09845	7K	Elk/Pequea/Octoraro	Lancaster/Chester
*4	2.29164	12A	Juniata River	Mifflin/Juniata
*5	1.61897	4C	Towanda Creek	Bradford
*6	1.32724	13C	Conococheague/Antietam	Franklin/Adams
7	1.09567	11D	Raystown Branch	Bedford/Huntington
*8	1.01514	11A	Frankstown Branch	Bedford/Huntington/Blair
*9	0.90189	7D	Swatara Creek	Berks/Dauphin/Lebanon/Schuylkill
10	0.53899	12B	Tuscarora/Buffalo	Perry/Juniata/Huntingdon/Franklin
*11	0.48927	7B	Conodoguinet	Cumberland/Franklin
*12	0.47680	4D	Wyalusing Creek	Bradford/Susquehanna/Wyoming
13	0.39506	13B	Licking Creek	Fulton/Bedford/Franklin
*14	0.39321	10C	Buffalo/White Deer	Union/Lycoming/Centre
15	0.39291	4G	Meshoppen/Mahoopany	Susquehanna/Wyoming/Lackawanna
*16	0.38065	9C	Bald Eagle Creek	Centre/Clinton
17	0.31163	5A	Lackawanna River	Lackawana/Susquehanna/Luzerne/Wayne
*18	0.29498	7H	Codorus Creek	York
*19	0.25436	6C	Wiconisco/Mahantango	Northumberland/Dauphin/Schuylkill
20	0.22349	4E	Susquehanna/Snake Creek	Susquehanna/Wayne
*21	0.20149	6A	Penns/Middle Creek	Snyder/Union/Centre/Mifflin
*22	0.18728	7I	Muddy Creek	York
23	0.16430	10B	Loyal Sock	Sullivan/Lycoming/Bradford
24	0.12569	10A	Lycoming Creek	Lycoming/Tioga/Clinton
25	0.08261	7A	Shermans Creek	Perry
*26	0.07181	7E	Yellow Breeches	Cumberland/York/Adams
27	-0.05921	12C	Augwick Creek	Huntingdon/Fulton/Juniata/Mifflin
28	-0.11260	4B	Susquehanna/Bentley Creek	Bradford/Susquehanna/Tioga
*29	-0.14615	6B	Shamokin/Mahanoy	Northumberland/Schuylkill/Columbia
30	-0.18599	13A	Wills/Evvitts Creek	Bedford/Somerset
*31	-0.23586	4F	Tunkhannock	Susquehanna/Wyoming/Lakawanna
32	-0.30033	11B		
33	-0.34348	11C		
*34	-0.41536	13D	Marsh Creek	Adams/Franklin
*35	-0.42616	7F	Conewago	Adams/York
*36	-0.45282	5E	Catawissa Creek	Northumberland/Montour/Columbia/Sct
37	-0.46943	4A		
*38	-0.53631	5C	Fishing Creek	Columbia/Luzerne/Sullivan
*39	-0.58009	10D	Muncy	Northumberland/Montour/Lycoming
40	-0.60032	5D		
41	-0.62658	8B		
42	-0.80861	8C		
43	-0.88244	5B		
44	-0.89932	9A		
45	-0.07297	8A		
46	-0.14913	9B		
47	-0.22676	7C		
48	-0.70516	8D		

- - - - "NORM" cutoff

* Watersheds now participating in the Financial Assistance Funding Program

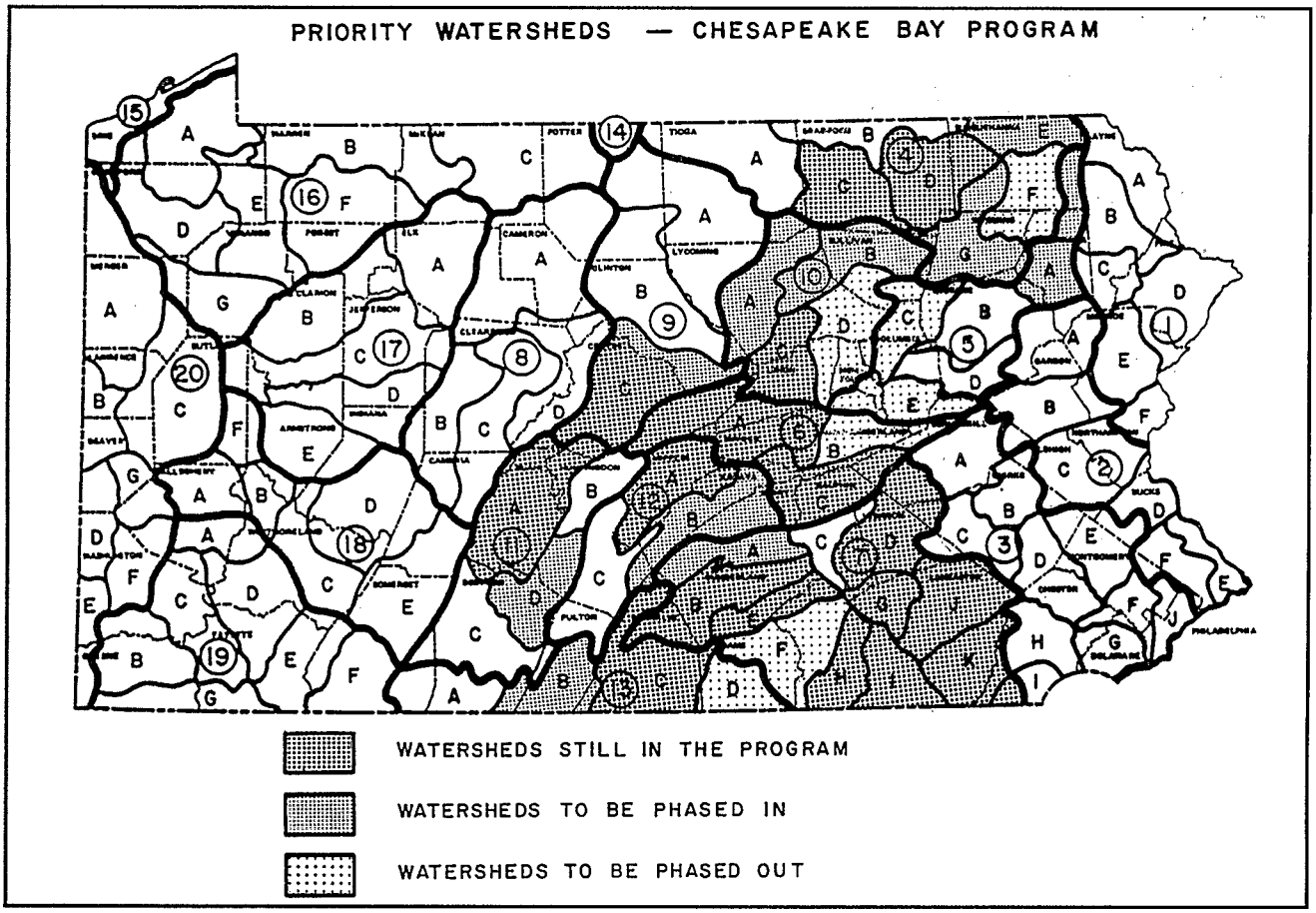

Figure 1. Selected watershed areas in Pennsylvania.

When this discrepancy was found, the BLWC decided to find a way to revise these data and minimize the level of error in the Animal Loading Index. It was decided to determine a conversion factor for each type of animal the Agriculture Census Bureau collects population numbers for. The conversion factor would define the pounds of nitrogen generated by each animal type. The Census Bureau could then take the animal populations in each ZIP code and compute a total pounds of nitrogen generated by the animals for each ZIP code. These data will replace the original data used and a new Animal Loading Index will be created. It is anticipated that this will also be completed by the end of 1994.

In addition to revising the 1987 Census data, the same conversion factors will be used to calculate pounds of nitrogen by zip code using the animal population data now being collected for 1992. Population trends and changes in animal loadings can then also be calculated to minimize the affects of the inaccuracies inherent in using these data.

Ground Water Index Development

The BLWC, in cooperation with ERRI, is now developing a ground-water pollution potential index to be added to the agricultural pollution potential index already developed. This project will use data from STORET and WATSTORE to develop a depth to water data layer. The geology of the state is being digitized by USGS and will be added to this data base. A pollution potential index by soil type for various pesticides has been developed by SCS and included in the STATSGO data base. Using DRASTIC, these data will be combined, and an agricultural ground-water pollution potential index developed for all 478 ground-water basins identified by the Department's Bureau of Water Quality Management. This project should be completed by the end of this year.

Conclusions

After using this GIS for several purposes over the last year, the following conclusions were reached:

1. This GIS is a good *statewide/ basinwide* planning *tool*. It can be used as a tool to help screen and prioritize watersheds for further analysis and activities. It is a good way to begin the process of targeting resources to ensure that they are used where they are needed the most.
2. If the intent of using a system such as GIS is to do detailed assessments or to prioritize at a fine scale, more detailed resolution is needed than the 1:250,000 scale used. It is recommended that a scale of 1:100,000 be the starting point, but finer resolution of 1:24,000 may be needed, depending on the intended use of the GIS.
3. This system is very useful. However, there are limitations to the Agricultural Census data. Obtaining these data from other sources was explored and found to be infeasible at this time. If the inaccuracies are kept in mind, these data are still the most consistent, accurate data collected.
4. It must be recognized that if this system is to keep its utility as a prioritization and targeting tool, it must be constantly updated and enhanced. Costs and resources to maintain a system such as this should be identified before developing a similar GIS.

References

Petersen, G., et al. 1991. *Evaluation of agricultural pollution potential in Pennsylvania using a geographic information system.* ER9105.

The Colville River Watershed Ranking and Planning Project

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The Colville River Basin encompasses approximately 263,000 hectares (650,000 acres) in Stevens County in the northeast corner of Washington (Figure 1). The 53-mile-long river is a tributary of the Columbia River, flowing into the portion of the Columbia known as Lake Franklin D. Roosevelt. The headwaters of the Basin are in the Loon Lake area and the river flows north to its confluence with the Columbia River just south of Kettle Falls.

The Colville River Basin is mainly rural with a rich valley bottom, ranging in width from 1 to 3 miles, bordered by forested foothills and mountains. Approximately 25,000 people live within the Basin. There are five cities ranging in size from 200 to 5,000 people.

Much of the Basin's economy is natural resource based. Beef, grain, hay, and milk production are important economic factors. Logging and the milling of logs are also vitally important with four large mills being located in the Basin. Federally administered, forest industry, state, and small privately owned lands provide the logs needed for these mills. The Basin is rich in minerals, and mining and processing operations exist in Addy and the area around the town of Valley (Figure 1).

The Stevens County Conservation District received a grant from the Washington State Department of Ecology in 1991 to conduct the Colville River Watershed Ranking and Planning Project. The funding for the project was provided by the State of Washington Centennial Clean Water Fund which is generated by a state tax on tobacco products. The purpose of the project was to encourage, and to provide the opportunity for, local participation in watershed planning and management. The Department of Ecology realizes that these are important components in

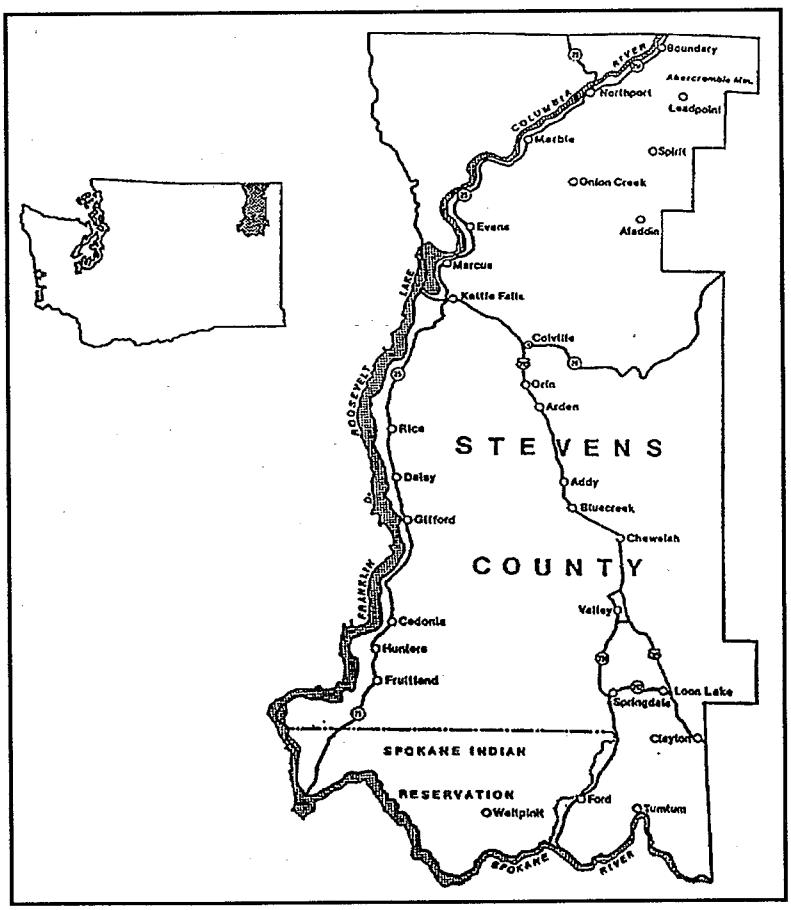

Figure 1. Vicinity map of Stevens County, Washington.

improving, maintaining, and protecting the quality of surface waters throughout the State of Washington.

The project had two distinct phases. The first phase involved looking at the entire Colville River Basin and ranking 19 watersheds within the Basin for the purpose of developing watershed management plans. The second phase, which is currently underway, involves developing a watershed management plan for the number one ranked watershed. This paper will discuss the watershed ranking portion of the project.

Watershed Ranking Project Objectives

The major objectives of the project were:

- Develop local committees to conduct a watershed ranking.
- Develop watershed ranking criteria.
- Review information on the physical and human environment and the water quality within each of the designated watersheds.
- Rank the watersheds, based upon review of this information, for the development of watershed management plans that would enhance, maintain, or protect water quality.

Watershed Ranking Project Overview

Committee Development

A Technical Advisory Committee (TAC) and a Watershed Ranking Committee (WRC) were developed. These committees met on a monthly or biweekly schedule during the course of the project.

The membership of the TAC included representatives of:

- Washington State Agencies: Department of Natural Resources, Department of Ecology, Department of Transportation.
- Soil Conservation Service.
- Local Agencies: Stevens County Planning Department, Northeast Tri-County Health District.
- Lake Roosevelt Water Quality Council.
- Stevens County Conservation District.
- Arden Tree Farms.
- Boise Cascade Corporation.

The role of the TAC was to provide assistance to Conservation District staff in all phases of the project and to provide technical support to the WRC during the ranking process. The TAC supported the water quality monitoring portion of the project by reviewing the Monitoring and Quality Assurance Plan and commenting on water quality data as it became available. Committee members participated in the watershed characterization by:

- Aiding in the delineation of watersheds within the Basin.
- Aiding in data collection by recommending possible data sources, providing the required data, and/or commenting on the appropriateness of certain pieces of information.

The WRC was composed of 18 members representing diverse interests within the Basin. The Conservation District wanted to ensure that all interested parties were asked to participate in the ranking project from its beginning. While some parties were unable to participate due to time constraints, all asked to be kept informed of the progress of the project.

The membership of the WRC included representatives of:

- *Agriculture.* Stevens County Cattlemen's Association, a dairyman, a hay and grain producer.
- *Environmental groups.* Washington Environmental Council, Inland Empire Public Lands Council.
- *Forestry.* Washington State Department of Natural Resources, Vaagen Brothers Lumber Company, Boise Cascade Corporation, Arden Tree Farms, U.S. Forest Service, Washington Farm Forestry Association.
- *Local agencies.* Tri-County Economic Development District, Washington State University Cooperative Extension, Stevens County Conservation District.
- *Local government.* City of Chewelah, City of Kettle Falls, City of Colville, Stevens County Commissioners.

The WRC chose consensus as the preferred method of decision making. Although uniform agreement may not always occur, each party gains a better understanding of other members' perspectives. The WRC felt that while consensus may require more time to reach a decision, it

should reduce the possibility of alienating members from the decision-making process. It was agreed that if a member strongly disagreed with a committee decision, they could write a dissenting opinion that would become part of any document produced by the committee.

The WRC developed a criteria for ranking the Basin's watersheds. These criteria also provided an outline of data needs for each watershed. The committee developed a two phase criteria. Phase One considered:

- Current threats to beneficial uses.
- The likelihood of intensified land or water use in the future.
- Environmental factors that increase the probability of water quality degradation.
- A comparison of contamination produced by the watersheds.

Phase Two considered:

- The likelihood of success of nonpoint source control programs based upon the interest in the watershed in developing and implementing a watershed management plan.

Each phase was worth 100 points.

Water Quality Monitoring

A water quality monitoring program was established to evaluate the current water quality in the Colville River and selected tributary streams. Twenty-five sampling sites were selected, 10 in the river and 15 on tributaries. Tributary sampling sites were located as close to the mouth of the stream as possible to characterize what was being delivered to the river.

Twenty sampling periods were established for calendar year 1992. Samples were taken once a month with the exception of the high flow months (April and May) and the low flow months (September and October). Samples were taken three times a month during these times.

At each sampling site, information was obtained on flow, dissolved oxygen, temperature, conductivity, total dissolved solids, pH, ammonia, nitrate-nitrite, total phosphorus, total suspended solids, and fecal coliform. Metal samples were collected at selected river sites. These samples were analyzed for copper, lead, zinc, iron, magnesium, manganese, aluminum, and hardness.

The WRC was provided with water quality monitoring results in tabular and graphical form. The committee was provided with graphical comparisons of the relative contributions of the various watersheds to the Colville River. Pie charts were used to represent the relative contribution of flow, ammonia, nitrate-nitrite, total phosphorus, total suspended solids, and fecal coliform.

The WRC was provided with supporting information on Washington State water quality standards and results of water quality sampling on other rivers and streams in eastern Washington and northern Idaho. Presentations were made to the WRC on the role of riparian areas in nutrient cycling and the effect of nutrients in an aquatic environment. This information helped the committee better assess the water quality situation in the Colville River Basin.

Watershed Characterization

The initial phase of the watershed characterization involved delineating 19 watersheds within the Colville River Basin. Most of the watersheds were delineated based upon the area drained by the major tributaries to the Colville River. In three watersheds, no one significant tributary characterized the area so these watersheds contained a number of smaller streams draining to the Colville River.

Once these watersheds were delineated, work commenced on gathering information needed for the ranking. This included information on:

- *Topography.* Basin relief and watershed maps were provided.
- *Soil.* Soils were classified based on Soil Conservation Service hydrologic soil groups and the acreage in each group reported. Hydrologic soil groups classify soils according to their runoff producing characteristics.
- *Land use.* The area within each watershed was delineated as being forested, open or urban/industrial. Information on agricultural land use within each watershed was provided with emphasis placed on animal raising activities.
- *Wildlife.* The Washington Department of Wildlife provided estimates for selected species based upon hunting information. It was noted that the survey was not exhaustive and that certain species might exist in a watershed that were not reported.
- *Hydraulic projects.* Any form of work that uses, diverts, obstructs, or

changes the natural flow or bed of any fresh water of the state, requires Hydraulic Project Approval (HPA) from the Department of Wildlife. The number of permits granted since 1980 and the activities conducted under each permit were provided for each watershed.

- *Building plats.* The information included the number of plats recorded by the County Planning Department from 1972-1989. The range of plat sizes, the average plat size, and the average lot size were reported when the appropriate information was available.
- *Septic tanks.* The number of permits issued, the total gallons of new septic tanks, and the total feet of new drain field were provided for the period from 1966 to 1992.
- *Forest management.* Forest practices information was gathered from the Washington Department of Natural Resources for areas within one mile of the major streams within each watershed. The information reported included the number of permits by year, acres or miles of road to be managed, percent removal, and water type affected by the activity.
- *Road projects.* Stevens County Public Works Department and the Washington State Department of Transportation provided information on annual road maintenance and proposed road improvement projects for the next six years.
- *Environmental complaints.* The Department of Ecology provided a list of water-related complaints they had received for the Colville River Basin in 1991.
- *Wetlands.* The total acreage of areas designated as wetlands and open water was provided for each watershed.

In addition, the WRC was provided with a series of maps showing prime agricultural land and woodland, average annual precipitation, generalized land use, land ownership, and deer wintering and feeding areas in the Colville River Basin.

The Ranking Procedure

The Watershed Ranking Committee worked from October 1991 to November 1992 to rank the 19 watersheds. Three meetings in October 1991 provided the WRC with general project information and produced guidelines for WRC conduct and the previously mentioned set of ranking criteria. The WRC agreed to stand adjourned until data became available for use in the ranking process.

The WRC was encouraged to attend two tours prior to the commencement of formal meetings in July 1992. The first tour concentrated on stream dynamics and water quality monitoring. The second tour was designed to inform the WRC of local water quality concerns and some of the Best Management Practices (BMPs) currently employed to address those concerns. Much emphasis was placed upon local efforts to address local concerns during both tours.

The WRC met every 2 weeks for 5 months to complete the formal ranking process. The committee was provided with water quality monitoring results, supporting water quality information, and watershed characterization data for each of the 19 watersheds. Conservation District staff attempted to provide the background information necessary for filling out the ranking criteria without influencing committee members' decisions.

The Committee was informed that a current water quality problem need not exist in a watershed for it to qualify for development of a watershed management plan. The plan could be one of three types: an enhancement plan, a maintenance plan, or a protection plan based upon the current and projected future conditions within the watershed.

The WRC determined that each member should rank the watersheds on their own and then come together to discuss these so that committee members could share what they learned during the initial ranking. The greatest problem committee members encountered in the ranking was getting started. The amount of data provided seemed overwhelming to many members. The Conservation District offered to have a ranking workshop to allow committee members the opportunity to lay out the data for each watershed and systematically work through the ranking. Conservation District employees were available to provide assistance and answer questions.

The results of the initial ranking were based upon the ranking position given to each watershed by individual committee members. The ranking values for each

watershed were summed and the watershed with the lowest total was ranked number one and the one with the highest total number nineteen. As an example of this method: a watershed ranked first on 10 forms would receive 10 points while one ranked tenth on 10 forms would receive 100 points. Watersheds were ranked one to nineteen with allowance being made for ties.

The Committee decided to tour four of the top ranked watersheds to provide a visual assessment to support the watershed characterization data. This tour was conducted during one day using one vehicle able to carry all the participants. The committee felt these were important aspects of the tour because they would ensure that the same members would see all four watersheds and the discussion between sites could involve all participants.

Immediately after the tour, committee members re-ranked the four toured watersheds. The previously ranked number one and number two ranked watersheds changed positions as a result of the tour. Factors involved in this change were relative sizes of the watersheds, apparent development pressure, presence of sediment throughout the system, and the affect of the stream on a municipal area. While this information was available in various forms in the watershed characterization, the tour allowed committee members to make a rapid assessment of the conditions in each watershed.

Questionnaires were sent to each of the watersheds toured. A cover letter; an article on the overall project; and an addressed, stamped envelope were included with each questionnaire.

The questionnaires asked:

- Does a stream or river flow through your property?
- Do you feel there is a water quality problem in your area? Please explain.
- Do you perceive a potential water quality problem in your area in the future? Please explain.
- If a local water quality effort is established in your watershed to maintain or improve the water quality, are you willing to be involved at some local level? If the answer was yes, the respondents were asked if they would attend seminars, be a member of a planning committee, hold a public meeting in their home, or participate in a stream enhancement activity.

The response to the questionnaire was excellent with between 37 percent and 46 percent responding from the various watersheds.

Two public meetings were held, one in the northern portion of the Basin and one in the southern portion. Information was provided on why the Conservation District got the grant, the goals of the overall project, and how the watershed ranking had been developed. WRC members spoke about what they considered during the ranking and provided insight into why they ranked the watersheds as they did. During the discussion, special emphasis was placed on the highest ranked watersheds in each portion of the Basin.

In developing the final ranking, the WRC focused heavily on the likelihood of increase in the intensity of land or water use in each watershed and evidence of the presence of contaminants and their impact. Stevens County and the Colville River Basin appear to be on the verge of an increase in population and this potential was reflected by the ranking. The current contribution of flow and nutrients to the Colville River by each monitored tributary was also given significant weight. The fact that there have been few reported incidents of impairment or threats to beneficial uses of water within the Colville River Basin was also reflected in the ranking. The environmental conditions that could produce a potential increase in water quality problems were generally considered to be fairly uniform throughout the Basin.

The 26,900-hectare (66,475-acre) Chewelah Creek Watershed was ranked number one. Factors affecting the selection were:

- *Size.* It is the third largest watershed in the Basin.
- *Land use.* The watershed has a variety of land uses with federal, state and private timberland in the headwaters areas, agricultural activity in much of the Basin, and a municipal area of 2000 people near its mouth.
- *Recreational use.* The Creek is the site of recreational activity along its entire length with heavy pressure being applied in a city park in Chewelah.
- *Water quality.* The Creek contributed 21 percent of the nitrate-nitrite

delivered to the Colville River and 12 percent of the flow during the 1992 sampling periods and while the geometric mean for fecal coliform was below the state standard, 40 percent of the samples exceeded the standard.

- *The future.* Chewelah has received much national attention as a wonderful place to live, a 200-home development is being built in the watershed, and there is a strong possibility that large single-owner tracts will be broken into 10-20-acre parcels throughout the watershed.

Summary

The Colville River Watershed Ranking Project brought together a diverse group that contributed over 500 volunteer hours to rank the 19 watersheds within the Colville River Basin. The final ranking has provided direction for the Stevens County Conservation District's Long Range Water Quality Plan. A management plan will be developed for the Chewelah Creek Watershed in 1993. Funding will be pursued so that management plans can be developed and implementation projects conducted for the top five ranked watersheds over the next decade.

Watershed Simulation Modeling with GIS in Prince George's County

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The NPDES storm water permit regulations resulting from the Clean Water Act Reauthorization of 1987 require counties and municipalities to develop comprehensive storm water management programs. For large, complex urban fringe areas such as Prince George's County, MD, prioritizing storm water problems and developing cost-effective management techniques are primary objectives if program resources are to be efficiently allocated. The geographic information system (GIS)-based Watershed Simulation Model (GWSM) was designed to accomplish these objectives. GWSM enables planning assessment at the watershed level, estimating pollutant loads and flows for current land use conditions, and estimating future build-out scenarios with or without structural controls. At the small basin level, alternative storm water control scenarios can be evaluated for user-defined areas.

Previous Studies

GIS is increasingly being used for watershed assessment in support of various water resources programs (DeVantier and Feldman, 1993). The review of available literature shows that the use of GIS in conjunction with hydrologic models comprises a major part of the current activities. The use of GIS for hydrologic modeling can be divided into two general approaches: (1) performing watershed modeling analysis directly within a GIS package using empirical or lumped models and (2) processing input data for use with a separate or partially linked watershed model.

Empirical modeling within a GIS environment includes an approach using the modified Universal Soil Loss Equation (USLE) for evaluating silvicultural activities and control programs in Montana (James and Hewitt, 1992). Tim et al. (1992) coupled empirical simulation modeling with a GIS to identify critical areas of nonpoint source pollution in Virginia. On the other hand, linked GIS and hydrologic modeling approaches include a study by Ross and Tara (1993) utilizing a GIS to perform spatial data referencing and data processing while traditional hydrologic codes performed the calculations for time-dependent surface- and ground-water simulations. Terstriep and Lee (1990) developed AUTO_QI, a GIS-based interface for watershed delineation and input data formatting to the Q-ILLUDAS model.

Modeling Approach—The Prince George's County GIS-Based Watershed Simulation Model

The GWSM developed for the Prince George's County storm water program combines results from a watershed model

with GIS analytic routines. Figure 1 illustrates this modular modeling approach. The GWSM uses a continuous simulation model to generate single land use water quality and quantity time series data. ARC/INFO, combining GIS coverages from various data bases, is used to select a watershed and determine its physical characteristics including drainage area and land use distribution (Figure 1). The single land use time series, along with the land use and drainage area files, are processed by a series of Fortran routines and analyses to determine watershed loads and summary statistics. Results can be interactively displayed for watershed comparisons and management assessment. As with AUTO_QI (Terstriep and Lee, 1990), the GWSM modeling approach uses the GIS to furnish data for use with a continuous simulation model. Unlike other approaches, however, GWSM utilizes preprocessed output from a watershed model to calculate storm flows and pollutant loads for the study watershed.

Although the Stormwater Management Model (SWMM) (Huber and Dickinson, 1988) was used for this application of GWSM, results from other continuous simulation models such as the Hydrologic Simulation Program-Fortran (HSPF) (Barnwell and Johanson, 1981) can also be included. This modular approach enables increased simulation accuracy as calibrated models become available. Further, several models can be used within a single application, combining the strengths of each. For instance, SWMM could be used for urban areas while HSPF is applied to agricultural lands within a single study area.

Input Data Requirements

GWSM requires both ARC/INFO vector coverages and continuous simulation model output for each land use type modeled. Coverages include watershed boundaries and current land use files. Input data for SWMM include parameters for the rainfall, temperature, and runoff blocks for each of nine homogenous land use files.

A Case Study—Collington Branch Watershed

Water resource managers face multiple questions on how to best manage storm water on a regional, watershed, and sub-basin scale. For Prince George's County, an area covering over 480 square miles, there are 41 watersheds of varying size and land use distribution. The proximity of the county to the fast growing metropolitan Washington, DC, area makes storm water management a complex and pressing problem.

An assessment of the predominantly forested and agricultural Collington Branch watershed, covering approximately 14,820 acres and draining to the Western Branch and to the Patuxent River, was performed as a demonstration of the GWSM. Figure 2 presents the watershed selection screen from the GWSM, including the land use distribution for the Collington Branch watershed. This case study demonstrates how the GWSM can be

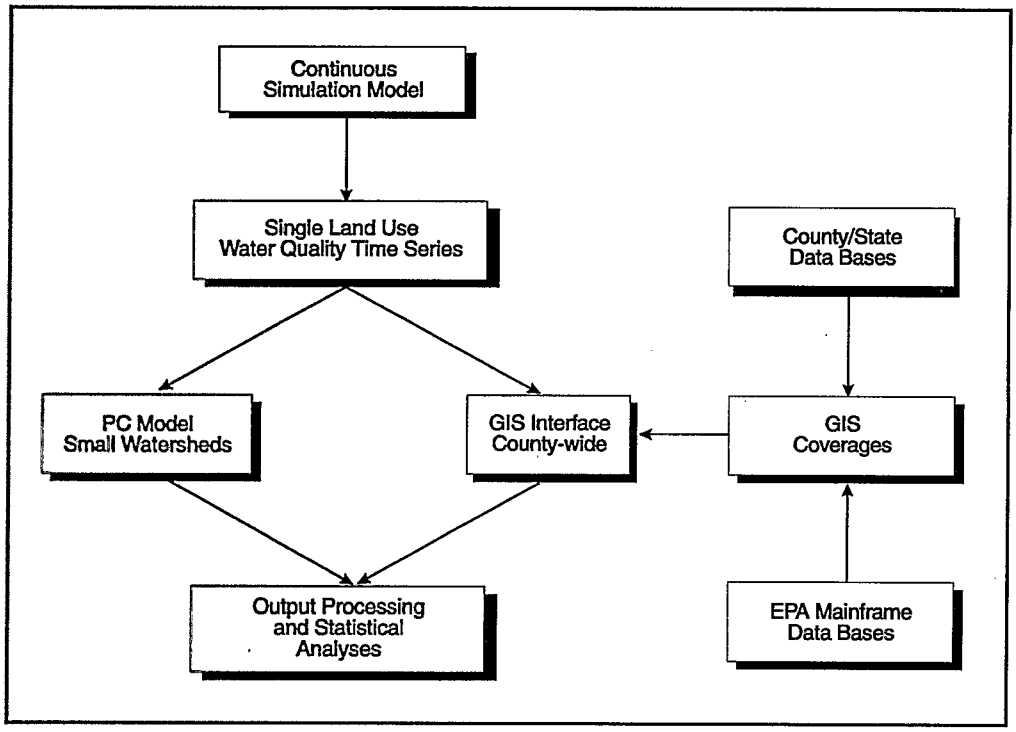

Figure 1. Conceptual design of the planning-level watershed modeling approach.

applied using a three-step approach: identify and target problem watersheds, identify pollutant sources and characterize pollutants, and conceptually identify control measures and evaluate future land use changes.

1. Watershed Problem Identification and Targeting

Often, the first question asked by water resource managers is: *How can problem watersheds be identified, and how do watersheds compare with each other in terms of pollutant loads and flows?* GWSM enables the rapid analysis of the relative contributions of each watershed to the total load, performing a complete assessment and interpretation of the data within 10 minutes. The results include estimates of annual, mean monthly, and monthly loads for the watershed for 12 parameters. Each constituent may be viewed either as a percentage of the total load, or in actual units (pounds or cubic feet). Figure 3 presents the graphical display from GWSM showing the total nitrogen load for the Collington Branch, illustrating the changes in loads due to climatic variability.

A comparison between two watersheds is easily performed to assess load and flow estimates and review results graphically. Multiple applications provide a rapid assessment of all the major watersheds in the county. This phase of the GWSM analysis provides information to answer the question: *Which are the likely water quality impacts and how significant are they compared to other watersheds?*

2. Identify Pollutant Sources and Characterize Pollutants of Concern

Once problem watersheds are identified and targeted for further analysis, the water quality problems must be clearly defined. *What are the sources of the pollutants of concern?* An analysis of the pollutant contribution by land use is included in GWSM, calculating constituent load by land use for each of the 12 parameters. Figure 4 shows total nitrogen contributions for each land use in the Collington Branch, indicting that agricultural areas are the primary source. This provides important information for targeting control programs throughout the watershed. Characterizing the pollutant loads is an important issue for developing management programs. Questions answered at this phase include: *What pollutants are of primary concern, what are their sources, spatial, and temporal characteristics; and how do their loads varying seasonally and annually, and what are the temporal variations between pollutants?* To

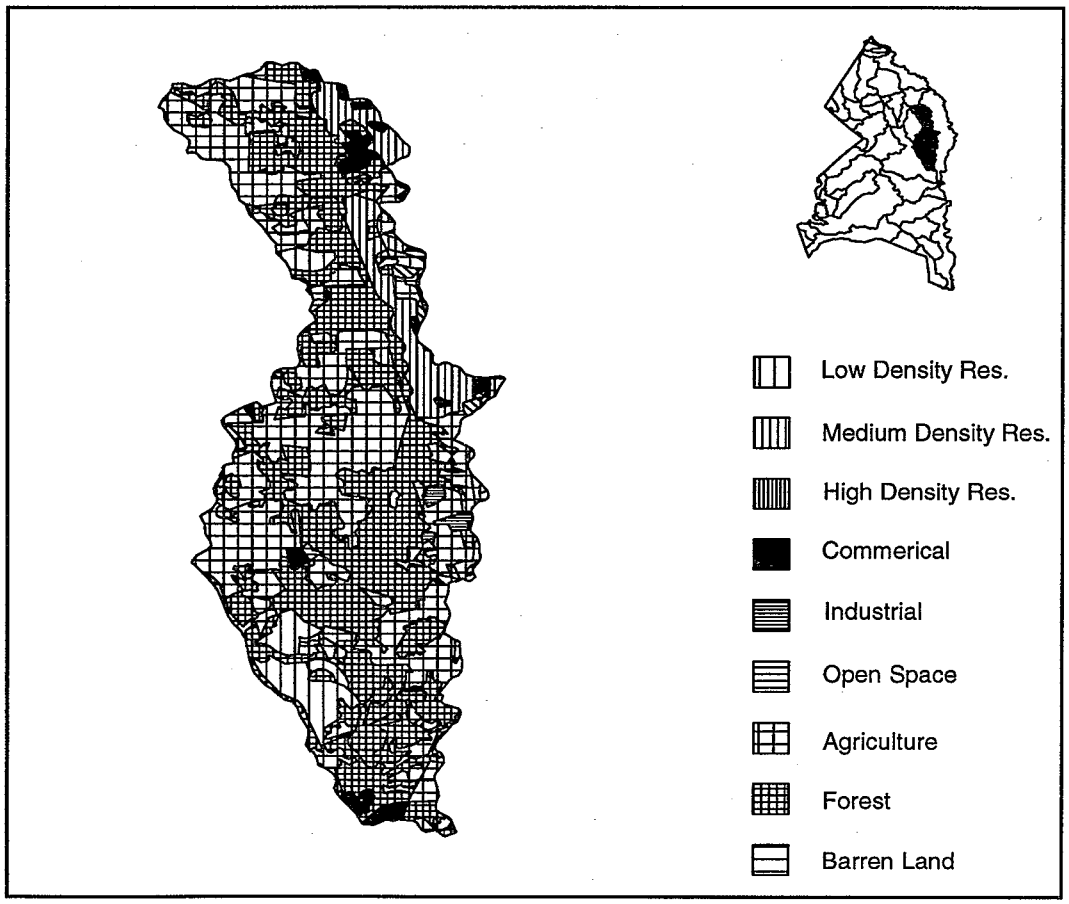

Figure 2. Collington Branch watershed.

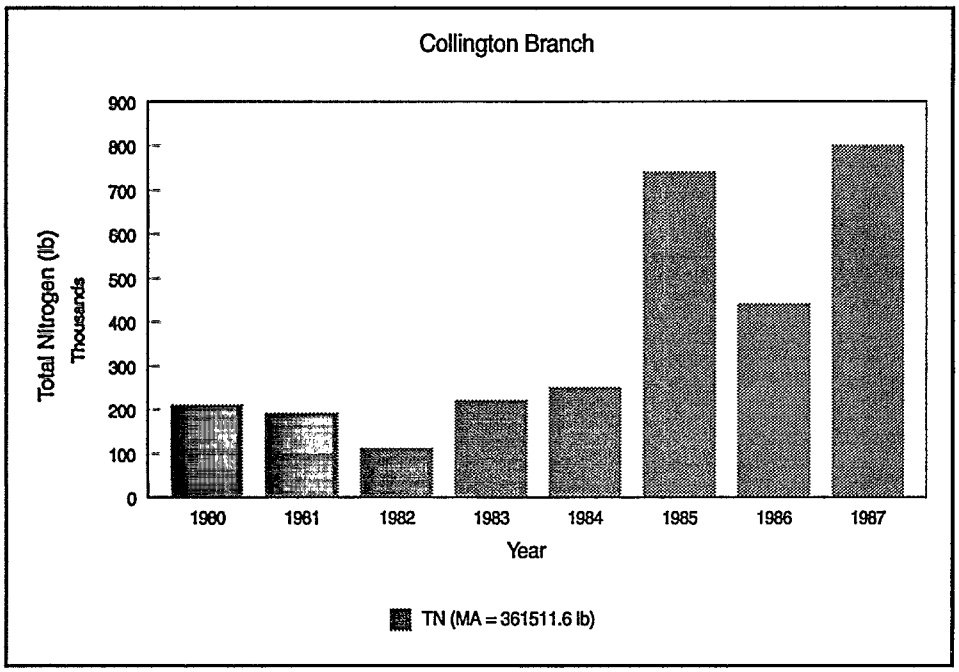

Figure 3. Annual summary of total nitrogen loadings.

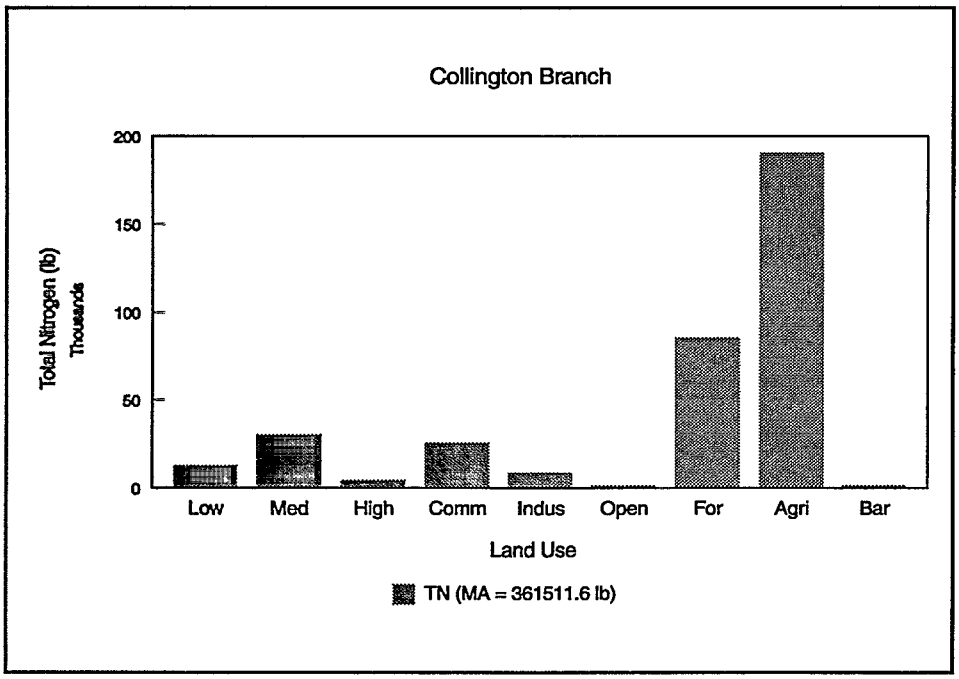

Figure 4. Distribution of total nitrogen loadings by land use type.

answer these questions GWSM provides graphical displays of mean monthly, mean annual, and annual pollutant loads for each pollutant.

3. Management Screening

In this phase, implementing the most cost-effective controls is addressed. In order to address control measures, the relationship between storm size, runoff volume, and pollutant load must be assessed. For example, *what storm sizes contribute the largest pollutant loads, and which storm size should be targeted?* The analytic routines in GWSM provide graphical answers to these questions. Figure 5 presents lead loads by storm size, indicating that by targeting only a percentage of runoff volume will control over half of the total lead load. Figure 6 illustrates the rainfall/runoff characteristics of the watershed; the majority of storms generate less than 0.05 inch of runoff. These estimates will vary by watershed; however, the advantage of GWSM is the rapid analysis of each pollutant, land use, and watershed.

Management evaluation is done at both the watershed and site-specific levels. *Over an entire watershed, what is the optimal control level for structural water quality facilities?* GWSM includes a storm water pond routine that calculates the pollutant-mitigating effects for different control levels and retention times. At a site-specific level, such as a proposed new subdivision, similar structures can also be evaluated to allow an optimal design criterion to be selected. Figure 7 illustrates the phosphorus contribution for a simulated residential subdivision, and the pollutant reduction from a storm water pond designed to control for 0.3 inch of runoff. As shown in the

figure, the mean annual phosphorus load was reduced from 453 pounds to 277 pounds by the simulated structure.

Managers must address how future changes will affect water quality. *On the watershed level, what will be the impact of urbanization on flow and pollutants loads? At the subbasin level, how will proposed projects change the runoff characteristics?* Both land use scenarios can be evaluated in GWSM. On the watershed scale the current land use can be interactively changed with a "point-and-click" menu. At the subbasin level a user-defined basin may be modeled, with the land use distribution entered into a pull-down menu. At both the watershed and subbasin level, once a land use scenario is selected GWSM calculates the anticipated pollution loads. The results can then be compared to the pre-existing conditions. The questions answered during the final phase of GWSM include: *How do pollutant loads relate to rainfall and runoff distribution and intensity? What is the optimal control level for structural practices? What are the likely impacts of future land use changes on water quality?*

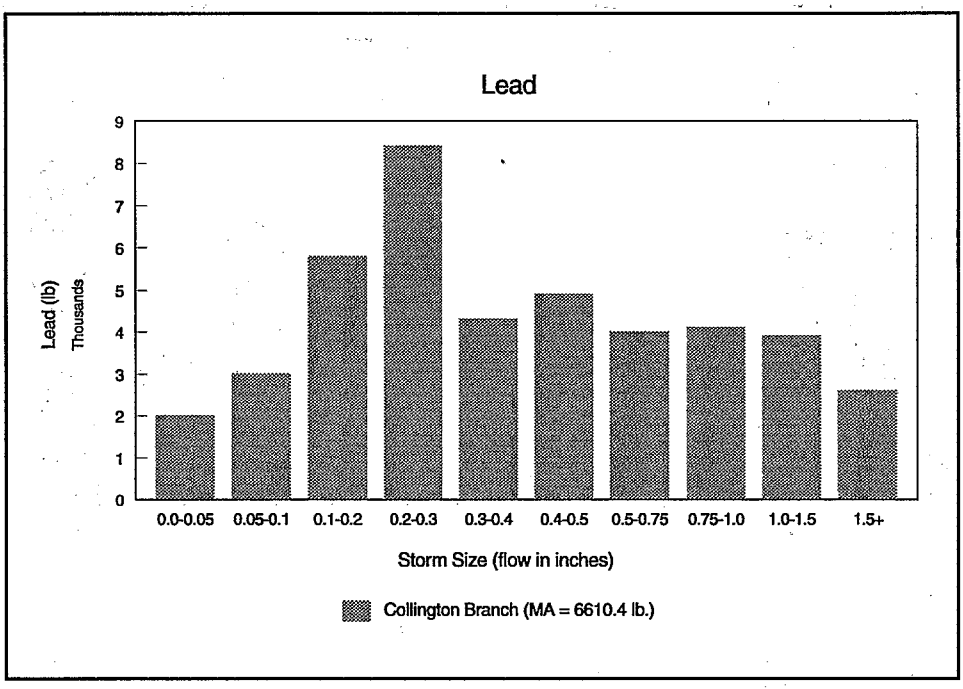

Figure 5. Distribution of lead loadings by storm size.

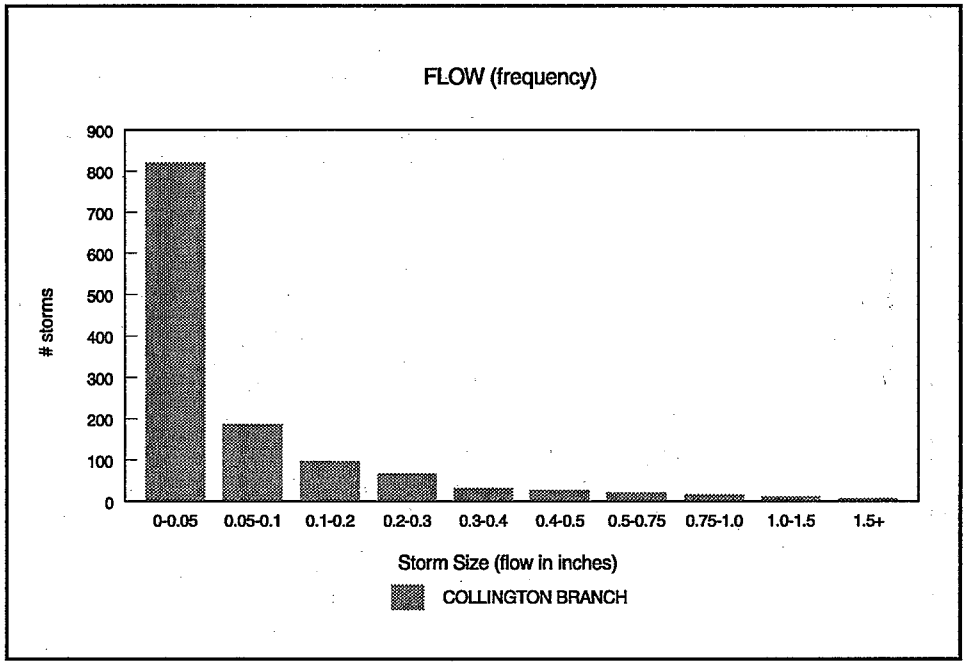

Figure 6. Flow distribution by storm size.

Storm Water Management—Future Model Applications

The NPDES storm water permit regulations have created new challenges and opportunities for state, county, and city water resource programs. Water resource managers are faced with often conflicting storm water management objectives and are forced to make decisions that must weigh the costs and benefits of each. For instance, water quality and flood control objectives do not always coincide. The design and management of regional storm water ponds will vary depending on whether water quantity or water quality control is the primary objective.

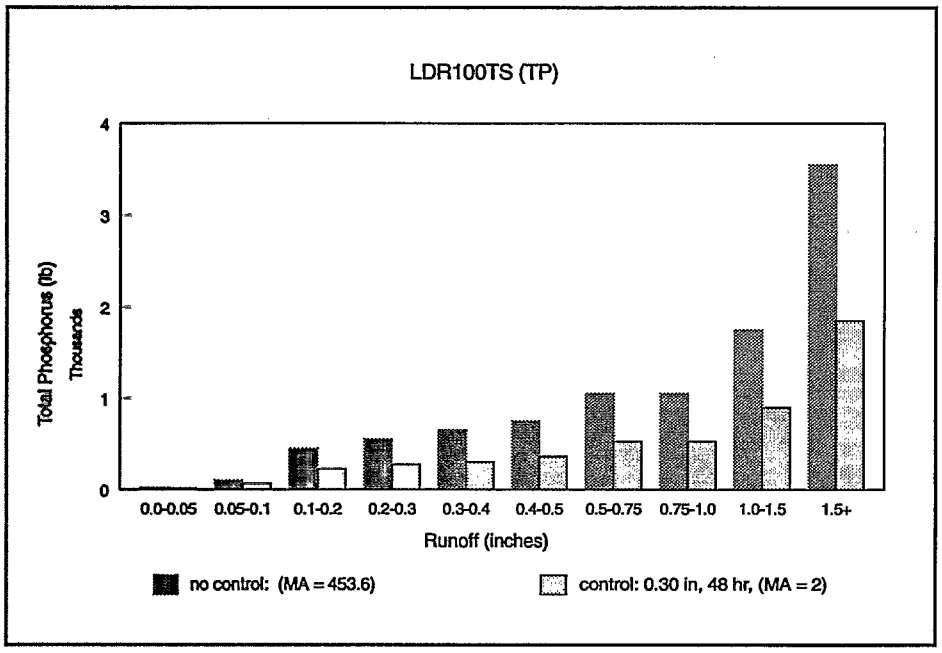

Figure 7. Phosphorus contribution by storm size: comparison of controlled and existing conditions.

To address the complex array of storm water issues, more sophisticated analytic tools and techniques will be needed. Watershed models that effectively evaluate alternative scenarios and allow for optimization routines for differing management objectives will be in demand. Integrating environmental data, such as wetland area and bioassessment information, structural and nonstructural BMP optimization, and permit and monitoring information, will be required in a user-friendly GIS package.

As the NPDES storm water regulations are implemented at the county and local level, unique management programs will develop according to the specific water quality and resource availability issues. As these programs take shape, GIS and GIS-based models and information management systems are likely to play a larger role for assessing problems and crafting solutions.

Conclusions and Recommendation

The GIS-based Watershed Simulation Model enables the rapid assessment of Prince George's County's storm water problem areas and the evaluation of control measures. The model incorporates the strengths of continuous simulation modeling with the spatial analysis techniques of GIS in an integrated system. Together the GIS and data processing routines allow for further analysis and interpretation of time series data from the SWMM model. Combining continuous time series data with georeferenced watershed/land use data allows for further analysis and interpretation of the results. As additional data from monitoring both homogenous land use basins and instream locations become available from the long-term monitoring program developed as part of the NPDES Part 2 permit, the accuracy of the model will be increased.

As technologies for developing and evaluating storm water programs increase in sophistication, the questions asked of water resource managers are likely to grow more difficult as well. The GWSM will continue to incorporate more functions designed to assist the managers in making the best possible, most informed decisions.

Acknowledgments

Prince George's County Watershed Protection Branch for their support of the model development; Prince George's County Park and Planning for the watershed delineation coverages; Maryland Department of Planning for the 1990 land use coverages of Prince George's County.

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Biodiversity Considerations in Watershed Management

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The role of watershed manager is probably changing faster than that of any other resource manager. Increasing demands for water, energy, timber, recreation, and other benefits provided by watersheds, coupled with growing awareness of the impacts of past management regimes on the physical and biological functions of watersheds, have expanded the realm of management far beyond the maintenance of water yield and water quality. Watershed managers are now faced with integrating the perspectives of hydrologist, forester, land use planner, economist, farmer, and ecologist. Watershed managers are being recognized as keepers of an array of resources, while continuing to provide water supply of sufficient quantity and quality for a growing human population.

The increased emphasis on multidisciplinary approaches to managing watersheds is comparatively recent. In western states, where National Forests provide a large portion of the water supply, watershed management has, for nearly a century, been directed by the Organic Act of 1897, which identifies water supply as the primary resource driving National Forest management (Smith, 1987). An example of this directive taken to an extreme was evidenced recently in California in a plan proposed to manage forested watersheds in the Sierra Nevada to maximize water yield. Proposed management tactics, which were designed to minimize evapotranspiration, interception, and infiltration, included extensive replacement of deep rooted vegetation (forest trees) with shallow-rooted herbaceous cover and grasses, shortened rotations of remaining timber to prevent deep rooted vegetation from reestablishing, and optimal use of impermeable surfaces to direct runoff to watercourses. The plan acknowledged that timber harvest and fisheries could suffer impacts and that significant structural support would be required to prevent erosion and sedimentation, and to maintain water quality, but argued that the economic value of increasing water yield could be sufficient to justify such costs. Clearly, the costs associated with severe ecosystem degradation as a result of implementing the plan were not considered in the analysis. While such plans are not likely to be considered seriously on even a limited scale, watershed management based on maximizing output of one or several resources without regard for the sustainability of the ecological complexes that provides those resources remains commonplace.

A recent inventory of several hundred western watershed management projects (Callaham, 1990) identified the patterns of degradation resulting from years of management focused on one or a few resources. Management to maximize water yield, timber harvest, grazing, and mining has resulted in erosion, loss of riparian and upland forests, reduced production and quality of grazing forage, reduced soil fertility, water quality degradation, reduced ground-water storage, fisheries decline, reservoir and stream channel sedimentation,

increased flooding flows, and loss of native aquatic and terrestrial species diversity. In short, watershed management practices have significantly impaired the ability of many watersheds to continue to provide the resources and services we expect to harvest from them. The most important consequence of this watershed inventory and assessment was identification of the need to develop watershed management approaches that provide for sustained watershed services and balanced resource output.

The services to which I refer constitute what have been more broadly termed *ecosystem services* (Ehrlich and Mooney, 1983). Ecosystem services, which include oxygen production, soil generation, maintenance of soil fertility, erosion control, organic waste disposal, nutrient cycling, production of fresh water, pest control, flood control, the basis of all agricultural and forestry resources and other species-derived products, and at a larger scale, regulation of atmospheric gases, precipitation patterns, and climate control, are provided by complexes of functional ecosystems. That is, functional, intact ecosystems provide services to our species without which we cannot survive.

The source of these services has come to be referred to as biological diversity or biodiversity. A truly operational definition of biodiversity would fill a library, but conceptually, biodiversity has been commonly defined as "the variety and variability among living organisms and the ecological complexes in which they occur" (Office of Technology Assessment, 1987). While this condensed definition has been widely used and accepted, it fails to explicitly communicate a component that is critical for the protection of biodiversity. Specifically, we must reword this definition to read "the variety and variability among living organisms and the ecological complexes in which they occur that maintain the support systems on which society is dependent."

The accelerating rate of loss of biodiversity has been of considerable concern to a growing number of biologists for several decades and recently has received a great deal of national and international attention. The effects of dismantling the ecosystem complexes that support us are most clearly evidenced by an unprecedented rate of species extinctions. This loss has been conservatively estimated at 4,000 to 6,000 species (Wilson, 1988) to as many as 90,000 species annually (Erwin, 1988). Loss of individual species, while critical, more importantly serves as a warning that our treatment of natural systems is destroying their ability to support us.

Awareness of this loss of biodiversity catalyzed the emergence of the discipline of conservation biology nearly 15 years ago. With roots in classical ecology, conservation biology initially followed a reductionist approach to conserving biodiversity, focusing on population phenomena within individual species known to be imperiled. To some degree, this approach has continued to be fostered by our interpretation of the federal Endangered Species Act, which focuses on single species and their often narrowly defined habitats, but which for many years has been the only enforceable statute available for biodiversity protection. Conservation biologists have learned in fairly short order that conservation strategies that are limited to single species protection are ineffective because they do not sustain the function of ecosystem complexes that allows species survival. This is not to suggest that protection of population and species levels of biological organization are not necessary, only that their protection is not sufficient to protect biodiversity (Noss, 1990).

In response to the realization that our conservation strategies have been to limited in scale, many conservation biologists have begun to incorporate higher levels of biological organization into planning for biodiversity protection. The emerging perspective that has shifted focus to higher levels of organization has adopted concepts from the discipline of landscape ecology.

Quite simply, landscape ecology addresses the dynamics within ecological mosaics that vary in scale and degree of connectedness. Most fundamental is that the components of these mosaics do not exist in isolation, but constantly interact, exchanging energy, nutrients, water, and organisms, as well as experiencing ecological succession and disturbance regimes through time. Recognition of the importance of these interactions between landscape components to the sustainability of ecological function has pointed to landscape ecology as the source for developing the management regimes required to protect biodiversity. The connection here to watershed management is straightforward. Watersheds, which are composed of multiple connected ecosystems that experience temporally and spatially dynamic phenomena, may be considered as landscapes.

John Wiens, last year, assessed the function of landscape ecology as an applied discipline by evaluating the content of the papers included in the first five volumes of the journal *Landscape Ecology* (Wiens, 1992). He found that nearly three-fourths of the papers were primarily descriptive or conceptual with limited or no quantification of results, and that concepts were rarely mathematically formalized, much less experimentally tested, with the exception of a small, well-defined emphasis on computer simulation and modeling. So, while the tenets of landscape ecology provide watershed managers with a theoretical framework from which effective management strategies may emerge, there is much work to be done. Delimiting and refining management techniques from the existing theoretical framework will require extensive information flow and feedback between researchers and managers in order to test landscape-level hypotheses that currently exist as both verbal and mathematical models. Studies must be designed to address landscape-level dynamics that previously have only been inferred from the behavior of smaller scale systems. Watershed management programs can provide the venue for the execution of such studies, hypothesis testing, and information exchange and, in so doing, can contribute to development of the tools that watershed managers need to manage the full range of biological diversity of which they are stewards. With the papers that follow this morning, I hope we can begin this process.

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Ecological Perspectives on Silvicultural Nonpoint Source Pollution Control

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Since the passage of the 1972 Clean Water Act, greater efforts for attaining the Nation's water quality goals have been devoted to control of nonpoint source (NPS) pollution. Because of its complex nature and site-specific and source-specific characteristics, NPS pollution is not yet under control. It remains one of the most serious threats to the Nation's water quality. Silvicultural NPS pollution has been reported to be a widespread problem in 7 states (most in the Pacific Northwest) and a localized problem in 33 states scattered around the country (Myers et al., 1985). Since aesthetically pleasing forested watersheds normally provide high-quality waters for municipal water supplies, fisheries, and recreational activities, NPS control programs must be undertaken to protect these precious water resources.

In this paper, we discuss the progress in developing goals and strategies for water pollution control, as it relates to an integrative ecological approach to silvicultural NPS pollution control. Various water quality goals and assessment methods are integrated into a conceptual framework that illustrates the use of assessment results as feedbacks for controlling silvicultural NPS pollution. Characterization of potential and existing ecological effects is the first step and an important element for assessing ecological risk. As an illustration, we summarize the major ecological effects of forestry activities. Lastly, further research needs are identified for long-term, ecology-oriented NPS pollution control efforts.

Ecological Integrity—The Paramount Water Quality Goal

The principal objectives of the Clean Water Act are "to restore and maintain the chemical, physical, and biological integrity of the nation's waters." The interpretation of these objectives, which is important for the formulation and implementation of water quality management approaches, has been discussed extensively over the last two decades. Although biological integrity is explicitly mandated by the Clean Water Act, this aspect of water resources management has long been neglected (Karr and Dudley, 1981; Karr, 1991) as indicated by the fact that water quality traditionally has been interpreted as the physical properties and chemical constituents of waterbodies, and biological integrity has been assumed to be protected if the physical/chemical water quality criteria are met. Although some efforts have been made to use biological monitoring data for assessing water quality, e.g., indicator species and diversity indices, success has been limited because an integrative ecological approach was not employed (Karr, 1991).

Since the early 1980s, this situation has been steadily changing, as reflected by three major advances. First, new ecological principles and methodologies have been

developed for water resources management, e.g., integrative ecological indexes such as IBI (Index of Biotic Integrity) and ICI (Invertebrate Community Index), the ecoregion approach, and recognition of the importance of cumulative impact on aquatic ecosystems, as summarized by Karr (1991). Second, in recognition of the inadequacy of water chemistry and toxicity tests for successfully protecting water resources, the U.S. Environmental Protection Agency (USEPA), states, and scientific community have accelerated the development and implementation of biological monitoring techniques and biocriteria (USEPA, 1990). Third, the focus of environmental protection has been expanded from human health risk reduction to include ecological risk reduction (SAB, 1990). These theoretical and technical progresses have resulted in general acceptance of the concept of "ecological integrity" as the summation of physical, chemical, and biological integrity, which should be the highest and ultimate goal of water quality protection (Karr and Dudley, 1981; USEPA, 1990). Since "integrity" is a relatively abstract concept, it must be quantified by some kinds of criteria for water quality management purposes. As the biological criteria become increasingly reliable and provide better supplemental roles to the physicochemical water quality criteria, the next step seems naturally to be the integration of these criteria for developing aquatic ecological criteria (USEPA, 1992a).

For NPS pollution control, ecological integrity is even more important, largely for two reasons. First, many nonchemical stresses generated by land use activities (e.g., hydromodification, habitat degradation, etc.) have been recognized as the additional or more critical threats to the aquatic ecosystem health, in contrast to the nutrient and toxic effects typical of point sources. Second, NPS pollution, which is derived from episodic hydrologic events (rainfall and snowmelt), creates cumulative effects on aquatic ecosystems that can be better determined by biological monitoring because the resident biota are continuous monitors of the cumulative effects (USEPA, 1990). Moreover, in the case of silvicultural NPS pollution control, forestry operations usually are carried out in headwater, low-order stream basins where the aquatic ecosystems are significantly affected by their surrounding forested lands. Given the rapid response of forest streams, protection based on ecological integrity becomes even more important.

Ecological Risk Assessment—the New Paradigm of Environmental Assessment

NPS pollution control programs should include three major components: management mechanisms, environmental investigation approaches, and environmental criteria and assessment methodologies. These components can be used to establish a management framework that shows the interrelationships among each element (Chen et al., 1993). In this NPS management framework, the best management practices (BMPs) to be used are consistent with current forestry practices by the U.S. Forest Service, timber companies, and private landowners. Investigation techniques include direct methods (i.e., monitoring) and indirect methods (i.e., simulation modeling). These first two components are addressed elsewhere (Chen et al., 1993). In this paper, we focus on the third component, in which investigation results are used to assess the environmental effectiveness of proposed BMPs based on certain criteria.

In brief, environmental assessment methods and criteria include Physical/Chemical Impact Assessment (PCIA) based on Water Quality Criteria (WQC), Biological Assessment (BA) based on Biological Criteria (BC), and Ecological Risk Assessment (ERA) based on Aquatic Ecological Criteria (AEC), which can be summarized as a conceptual framework for silvicultural NPS pollution control (Figure 1). This framework uses an iterative process for determining whether to accept or to revise proposed BMPs based on assessment results and comprises three loops wherein three different assessment approaches and criteria are employed. While PCIA/WQC dominated in the 1960s-70s and BA/BC were emphasized in the 1980s, the importance of ERA/AEC is expected to be increasingly recognized in the 1990s as their theoretical and technical developments are accelerated.

Water quality assessments based on physicochemical criteria normally utilize traditional standards-based methods that have three weaknesses:

1. Single mean or extreme values only set up pass/fail standards, but environmental impacts are a continuum governed by various pollu-

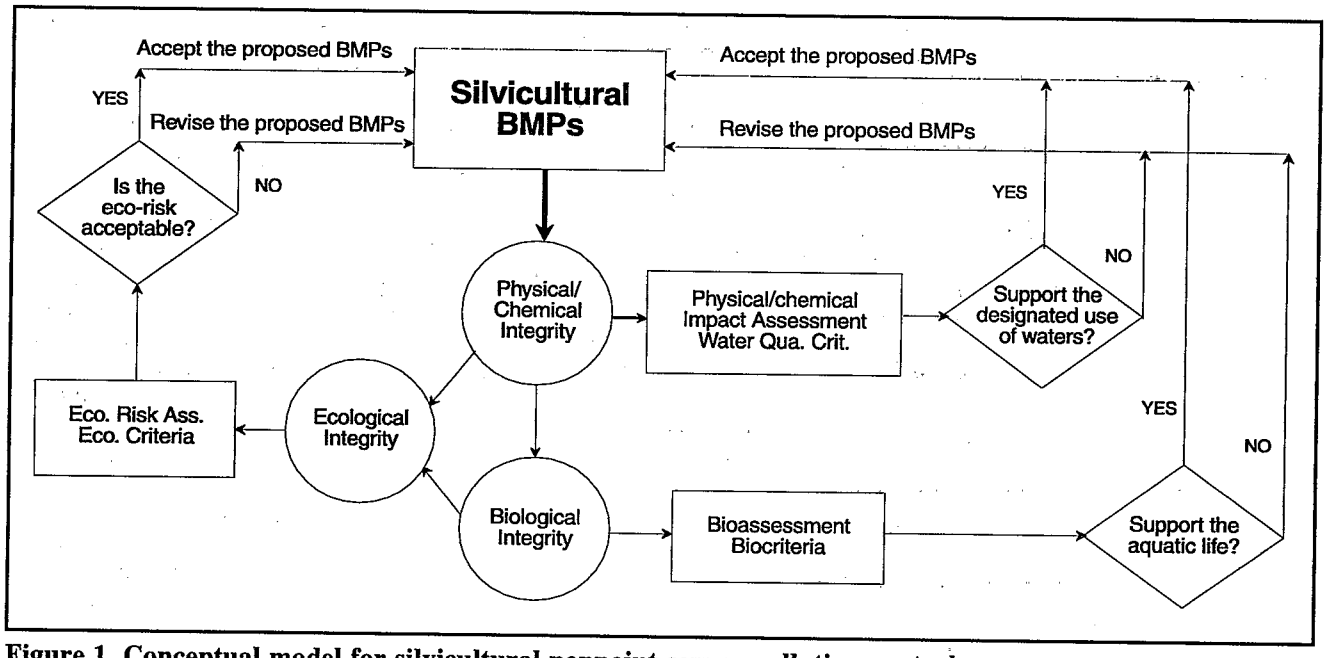

Figure 1. Conceptual model for silvicultural nonpoint source pollution control.

tion levels (i.e., concentrations or other quantities).

2. Standards-based assessment cannot explicitly quantify damages to aquatic ecosystems.
3. Uniform water quality criteria do not account for the natural variability of water quality due to geographic locations or different types of waterbodies. Although the third problem has been identified and overcome in the development of bioassessment techniques and biocriteria by using reference conditions at specific sites in an ecoregion, the traditional standards-based methods still dominate in the biological approaches.

Concurrent with the development and application of standards-based assessment methods, risk analysis has evolved into an organized approach with demonstrated utility in predicting weather, failure of engineered systems, and insurance claims (Suter, 1993). In recognition of the drawbacks of standards-based methods, EPA has long advocated the use of risk-based approaches to environmental assessment and management (USEPA, 1991). Although EPA has been concerned initially with estimating human health impacts associated with various levels of exposure to toxic and hazardous substances, the Agency has been broadening its risk assessment context to include the health of nonhuman biota. Chronic and cumulative nonchemical effects as well as chemical stresses have been determined to be the basis for future integrated approaches. The full integration of human health and ecological risk assessment is expected to be the new paradigm of environmental assessment for the coming years (Suter, 1993; USEPA, 1992b). Given the nature of silvicultural NPS pollution, it is especially important that in order to attain the integrity of forest stream ecosystems, the ecological risk imposed by silvicultural BMPs must be assessed based on ecological criteria, despite the formative nature of current criteria.

Ecological Effects of Silvicultural BMPs

Ecological effects of forest practices upon stream ecosystems have long been studied by many ecologists. Karr and Dudley (1981) identified four major categories of environmental factors that affect aquatic biota: flow regime, water quality, habitat structure, and energy sources. Besides the physical/chemical water quality, many other environmental parameters altered by forestry operations may affect stream ecosystems. MacDonald et al. (1991) provide the most comprehensive technical guide for water quality monitoring on

forested lands to date. They recommend that a total of 30 parameters or groups of parameters be used to determine silvicultural impacts. Based on a review of the literature, we first discuss the general characteristics of each category of environmental factors; then identify the most important parameters; and briefly summarize the alterations, mechanisms, and ecological effects for each of these parameters.

Flow Regime

Change of streamflow is one of the most noticeable impacts generated by forest activities. Numerous watershed experiments have observed increases of stream flows (Bosch and Hewlett, 1982) that cause various impacts on stream ecosystems (Table 1).

Water Quality

Table 2 summarizes the most important physical properties and chemical constituents of water affected by forestry activities. Water quality may affect biological integrity by directly causing mortality or may shift the balance among species as a result of subtle effects such as reduced reproductive rates or changing competitive ability.

Habitat Structure

The availability of both food and physical habitat is the fundamental basis for maintaining the life of aquatic organisms. Although some of the habitat characteristics are depicted by flow regime and water quality parameters, other habitat features need to be considered. These additional features primarily include the shape of stream channel, the structural attributes within stream channel, and the stability of streambanks (MacDonald et al., 1991). These complex and interactive features are much more difficult to quantitatively evaluate by using numeric parameters. Table 3 summarizes the four types of habitat alterations that have the greatest ecological significance.

Energy/Food Source

Flows of energy and substances determine the function and structure of ecosystems. For undisturbed, small, headwater, woodland streams, the primary energy source is allochthonous organic matter from terrestrial environments because the stream has little primary productivity due to heavy shading and low water temperature. Thus, the stream is in a heterotrophic state with dominant insects of shredders and collectors and invertivorous fish. These attributes of natural ecosystems may be changed by forest operations (Table 4).

Further Research Needs and Conclusions

Although we recognize that ecological integrity is the paramount water quality goal and that ecological risk assessment is the new paradigm for water quality protection, we also conclude that we still have a very long way to go in putting our ideal conceptual model into practice, because even the qualitative analyses of ecological risk of forest activities seem to be extremely complex. We therefore note several important needs for further research.

1. Long-term cooperative research efforts by ecologists, hydrologists and foresters will be needed to better

Table 1. Ecological effects of flow changes caused by forestry activities

Parameters	Alterations	Mechanisms	Ecological Effects
Peak flows, Low flows, Total water yield	Increased stream flows and water yield	Reduced evapotranspiration due to vegetation removal Reduced interception due to canopy removal Reduced infiltration due to soil compaction caused by logging and mechanical site preparation and hydrophobicity of soils after burning Increased rate of snowmelt	Reduced stream retention capacity, decreased availability of food and substrates for aquatic organisms; Increased size and frequency of peak flows causing significant habitat destruction

Table 2. Major water quality parameters affected by forestry activities

Parameters	Alterations	Mechanisms	Ecological Effects
Temperature	Increased water temperatures	Increases in solar radiation due to reduced shading	Lethal or sublethal effects on fish and invertebrates Effects on chemical reactions Effects on productivity and behavior of aquatic biota
Suspended sediment and turbidity	Increased sediment production is the most important problem	Soil erosion from road surface, road fills, slope failures associated with road building and maintenance Surface erosion from landings, skid trails, burned areas, slope failures associated with forest harvest	Toxic effects of pesticides and herbicides absorbed to sediments Eutrophication due to nutrients absorbed to sediments, especially phosphorus Decreases in primary productivity due to reduced light penetration in turbid water Inhibition of fish reproduction due to reduced intergravel DO and entrapping alevins or fry Impairment of fish feeding and growth due to reduced ability to capture prey in turbid water
Dissolved oxygen (DO)	Reduced DO	Heavy input of fine, fresh organic materials after logging Reaeration reductions due to sedimentation Saturated DO reductions due to increased water temperature.	Detrimental effects on metabolism of aquatic biota due to deficiency of DO Reduction in rate of organic matter breakdown resulting in unfavorable odor and water color
Dissolved nutrients	Numerous inconsistent study results Increased N and P likely	Organic matter and sediment input into stream due to logging Nutrient leaching after burning Forest fertilization, such as the use of urea	Toxicity to human and aquatic biota, mainly nitrate, nitrite, and ammonia Increases in primary production (e.g., bacteria and algae) and possibly secondary production (e.g., macroinvertebrates and fish) causing possible eutrophication
Herbicides Pesticides	Inputs of introduced chemicals	Direct overspraying and drift due to aerial application Transportation by leaching, volatilization, and sediment erosion	Direct toxic effects on aquatic biota, causing catastrophic drift, reduced benthic abundance, etc. Indirect effects on the community structure, e.g., dietary shifts due to reduction of prey

understand the complex ecological effects of forest activities upon stream ecosystems. The biological aspect of water resources management has been neglected for too long (Karr, 1991). Biological monitoring techniques and biocriteria need to be coupled to the major advances in stream ecology that occurred in the past two or three decades.

2. Risk-based approaches to environmental assessment and management have become traditional approaches in the EPA regulatory efforts. However, ecological risk has much broader significance than the traditional human health risk. The stress-response profile in eco-risk assessment is not simply a dose-response relationship and the

Table 3. Major stream habitat attributes affected by forestry activities

Attributes	Alterations	Mechanisms	Ecological Effects
Pool/riffle setting	Degradation in the number, size, and variety of pools	Increased sediment yields fill in pools Reduced input of large woody debris due to riparian vegetation cutting	Pools are more important habitat because they provide more stable substrates and flows and are prime fish spawning and rearing areas
Embeddedness	Increased embeddedness	Coarser particles on streambed are surrounded or partially buried by increased input of fine sediments	Biologically, little space for invertebrates, juvenile fish, and periphyton; reduced intergravel DO Decreased channel roughness affects stream hydraulics
Large woody debris (LWD)	Short-term increase and long-term decrease	Introduction of logging slash immediately after harvest Reduced input due to riparian vegetation harvest	Loss of pools as important fish habitats because LWD is a major structural agent forming pools Reduction of food availability because LWD can trap organic matter such as leaves and twigs
Bank stability	Reduced bank stability	Increased peak flows, size and flux of transported sediments resulting from various forest activities Grazing in riparian zone	Large amount of sediments by slumps and surface erosion from unstable banks into the stream Increased water temperature due to larger surface area exposed to solar radiation resulting from increased channel width after bank erosion Little or no riparian vegetation supported by actively eroding banks

Table 4. Major energy/food sources for stream ecosystems affected by forest activities

Parameters	Alterations	Mechanisms	Ecological Effects
Light and temperature	Elevated light intensity and temperature	Reduced shading due to riparian vegetation removal	Increased autochthonous production may shift the stream trophic state from heterotrophic (P/R<1) to autotrophic (P/R>1) Change of trophic condition affects species composition of algal community, e.g., filamentous green algae often increase in abundance Macroinvertebrate density may increase as a result of excess algal availability
Allochthonous organic inputs	Reduced quantity and quality of inputs	Vegetation removal	Switch in dominant benthic invertebrates, i.e., shredders become less important while the production of scrapers and collectors increases

traditional quantitative methods (e.g., quotient and continuous methods) for risk assessment are not applicable. Although some efforts have been made to assess the ecological risks associated with chemical exposure (Suter, 1993), ecological risk assessment for controlling NPS pollution generated by land use activities is almost a virgin area so far. New theories and methodologies for ecological risk assessment will need to be developed.

3. Although the "magnitude" of eco-risk can be generally expressed as the integration of risk severity (a "loss" function) and accompanying probability (Chen et al., 1993), it is very difficult to determine what properties and what level of biological organization should be assessed. To quantify ecosystem risk, some theoretical constraints such as the lack of a generally accepted definition of "ecosystem health" must first be overcome.
4. Ecological risk assessment should be integrated with water quality modeling for NPS pollution control. Although the general relationships for this linkage have been described (Chen et al., 1993), technical guidance for the practical integration of these two promising approaches needs to be developed.
5. As the procedures for ecological risk assessment are being developed, risk-based ecological criteria should be formulated in the meantime. The development of "aquatic ecological criteria" is in its planning stage (USEPA, 1992a). Progress in all five areas will ensure better water resources management in the next decade.

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Butterfield Creek Watershed Management: An Interagency Approach

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In the early 1980s, the Butterfield Creek watershed experienced several large flood events which filled both the flood-prone areas and the local government boardrooms to overflowing. Political pressure to end flooding led to the formation of a local steering committee whose focus was to get state and federal assistance to dam, divert, or detain the storm water.

The last 10 years have taught everyone involved many lessons in the complex world of storm water management. Local officials and floodplain residents began with a hope that somebody else would provide a relatively quick solution with lots of money. The reality has been a study in self-help and intergovernmental cooperation with very limited funding. The Butterfield Creek story is a series of multi's: multi-community, multi-agency, multi-objective. What was learned can be applied by others in their watersheds.

The Butterfield Creek watershed is a 6,735-hectare (26-square-mile) area located approximately 48 kilometers (30 miles) south of Chicago, IL. Portions of eight communities are located in this watershed. Approximately 60 percent of the watershed is developed with typical suburban land use, 23 percent is still being used for agricultural production, and 15 percent is in public open space or is currently vacant waiting for construction of new developments.

Historically, the creeks draining the upper portions of the watershed were part of a wide, prairie wetland. As the creek proceeded downstream the terrain became steeper and the channel was much more defined. As farmers settled, farm tiles were installed, the upstream portions were drained, and the waters were carried away in small man-made channels. Early urban development was concentrated in the downstream portion of the watershed, primarily on the higher elevation lands and along the floodplain of Butterfield Creek. By 1980, new development had crowded out onto the natural floodplains and into wetlands and other natural storage areas through use of both drainage and fill.

These changes resulted in higher peak flows during storm events and significantly higher damages to the developed properties. The downstream communities were very concerned about what would happen when additional development occurred on the undeveloped land upstream.

Searching for Simple Solutions

The Butterfield Creek Steering Committee (BCSC), representing seven communities of the watershed and Cook County, was formed in 1983. The first action of the

Committee was to request the state and federal government agencies to stop the flood damages. The U.S. Soil Conservation Service (SCS) and the Illinois Department of Transportation, Division of Water Resources (IDOT-DWR), provided the first interagency cooperative response by conducting a study of flooding and flood damages in the watershed. Structural solutions were to be evaluated as part of the study and the local communities waited to see if these agencies would solve their problems.

In April of 1987, the SCS presented preliminary results of the floodplain management study to the BCSC and local citizens. The results presented were very disappointing to all in attendance. While substantial flood damages were identified, they were scattered and many different measures would be needed to significantly reduce the damages. The benefit/cost ratio for these upstream structures did not meet federal or state criteria for the expenditure of their funds to solve the problems.

Although the SCS floodplain management study (USDA-SCS, 1987) did not result in funding to solve the flood problem, it did identify three very important facts about the watershed. First, the current flood insurance maps for Butterfield Creek were inaccurate—the recalculated 100-year flood level was as much as 0.76 meters (2.5 feet) higher in some locations. Second, most detention standards for new development, in force in 1987, would not prevent increased flood damages in downstream areas (Bartels, 1987). Finally, the study identified the significant areas of natural storage in the upstream watershed. If this storage were to be removed, flood damages in the watershed would go up by at least 50 percent and possibly by as much as 500 percent.

Tackling the Complex

Recognizing their vulnerability, downstream communities requested, through the BCSC, the cooperation of all communities of the watershed in addressing the flood problems. If flooding could not be easily stopped, at least they could work together to plan and control their future before more of the watershed developed and flood damages increased. Recognizing that a commitment to help each other would benefit both upstream and downstream communities, all involved communities agreed to continue the BCSC efforts. Although there were no easy answers, it was understood that all seven communities, along with Cook County, were impacted by what happened in the watershed and along Butterfield Creek.

Organizing and staffing the BCSC was an immediate problem; fortunately, the Northeastern Illinois Planning Commission (NIPC), a regional planning agency for the six-county area of northeastern Illinois, agreed to provide basic help with agendas, mailings, minute taking, and some engineering evaluations. The IDOT-DWR agreed to provide a liaison to the Committee. Depending upon the particular need, the U.S. Army Corps of Engineers, the SCS, the U.S. Environmental Protection Agency (EPA), the U.S. Fish and Wildlife Service, and the Federal Emergency Management Agency (FEMA) all agreed to provide future assistance.

With multiple communities and multiple agencies around the table, the group began to tackle the complex task of storm water management.

Goal Setting

Goal setting proved to be a critical juncture for the Committee. This was when the participants discussed and concluded that flooding problems and environmental concerns were inextricably connected and that in order to tackle one, the other must be considered. Thus, the BCSC's goals became multi-objective:

- Reduce flooding and minimize streambank erosion in the Butterfield Creek drainage basin.
- Protect the storm and floodwater capacities of natural detention areas and protect wetlands for their resource management benefits.
- Preserve additional public open space to increase recreational opportunities (including trail facilities) to protect and enhance natural resource benefits, and to improve the environment within communities and neighborhoods.
- Improve the maintenance of streams in order to maximize natural water resource benefits and the aesthetics of stream corridors.
- Improve the quality of water in Butterfield Creek and its tributaries.
- Achieve a mutually supportive,

basin-wide management and regulatory framework for development activities affecting Butterfield Creek watershed.

Having agreed to goals, the Committee's next step was to create a model storm water management code for the communities. A state statute was passed in 1988 that mandated new floodplain regulations. This created an opportune time to review current ordinances and at the same time address some of the issues raised by the SCS study of the watershed. It was concluded that any code developed by the BCSC would address all issues of storm water management. The village engineer for one of the downstream communities worked with the NIPC staff to develop the Model Code (BCSC, 1990).

Highlights of the model code are:

- The storage capacity of those all important natural storage areas identified in the SCS study will be maintained.
- Detention requirements for new development were significantly strengthened. Release rates must meet 100-year storm limits of 0.0105 cubic meters per second per hectare (0.15 CFS per acre) and 2-year storm limits of 0.0028 cubic meters per second per hectare (0.04 CFS per acre). The 2-year requirement is to prevent increased erosion of downstream channels.
- The adverse water quality effects of new development are addressed by:
  - requiring effective erosion and sediment control;
  - encouraging *natural* drainage practices; and
  - requiring detention basin designs which enhance pollutant removal.
- The regulatory floodplains have been expanded to coincide with those defined in the SCS study.
- Very limited uses in the floodway, allowing only public flood control, public recreation and open space, crossing roads and bridges.
- Fees are allowed in lieu of detention for small developments where small individual detention basins for every site are not reasonable. This will require careful planning to create centralized detention at the needed locations.
- New developments along streams are required to have 22.8-meter (75-foot) setbacks with a 7.6-meter (25-foot) vegetated buffer strip along the stream.
- Site permits are required for all development. Development is defined as any man-made change to real estate. This regulation includes the grading of all private property including residential.
- All regulations related to storm water management are consolidated into this one code.

To date, five of the seven communities on the BCSC have adopted the model code. These five include all of the communities located in the upper portions of the watershed.

With stronger regulations adopted, the residents of the watershed threatened by floods have been given some insurance against worsened flood conditions in the future.

Hazard Mitigation Plan

In order to establish priorities for reducing flood hazards in the watershed, NIPC officials prepared options for Committee evaluation. This effort was funded by FEMA through IDOT-DWR, and the final product was a Flood Hazard Mitigation Plan (Price and Dreher, 1991) in which known mitigation options are described and recommendations for action are outlined. These recommendations are now before the policy boards of the watershed communities. It is hoped that each community will adopt the Hazard Mitigation Plan.

The Multi-Objective Approach: A Plan for Action

Discussions at the BCSC meetings in 1991 pointed out the need to develop an Action Plan. This plan, completed in 1992, combines the twin goals of mitigating flood hazards and protecting the watershed environment. The committee members divided the Action Plan into logical categories with members of the Committee taking leadership for a specific category. Highlights of the plan and accomplishments to date are as follows.

Natural Storage Acquisition/ Greenway Planning

A major element of the action strategy is preservation, and possible enhancement,

of the upstream natural storage areas. Public ownership of this land would meet the primary objective of flood control, but it could also satisfy other objectives such as passive recreation, preservation of open space and, in some cases, habitat restoration.

A key question is: Who will provide the funding? The open space benefits and some recreation advantages would primarily go to the community where the land is located. The flood storage benefits would accrue to both the community where the site is located and to downstream communities.

Recognizing these mutual advantages, the watershed committee has united behind an effort to secure funding for the acquisition of the natural storage areas. Short on funds, but long on cooperative and informed member communities, the Committee is now working with state agencies to tie down a quarter million dollars for land acquisition.

Part of the land targeted for acquisition lies within a greenway recently designated in the Northeastern Illinois Regional Greenways Plan developed and adopted by NIPC in cooperation with the Openlands Project, a private open space advocacy organization. It is hoped this will aid in obtaining additional funds to purchase the land identified.

Water Quality Management Projects

The water quality, aquatic habitat, and aesthetic conditions of Butterfield Creek are all degraded. Because there are no significant wastewater discharges to the creek, it was easy to conclude that identified problems are caused by nonpoint sources of pollution. With funding from EPA, the watershed was thoroughly evaluated and a preliminary nonpoint source management plan (Dreher et al., 1992) was developed. The study concluded that the major sources of stream degradation were urban runoff and stream channelization, with additional contributions coming from problem septic systems and illicit wastewater connections to storm sewers.

Many of the actions recommended were also included in the Flood Hazard Mitigation Plan (Price and Dreher, 1991). The plan identified the need for stringent controls on development similar to those in the Model Code (BCSC, 1990) with some enhancements. The plan recognized that public awareness and access must be improved; it specifically recommended the acquisition of riparian open space and the expansion of a streamside trail network.

Recognizing that implementation of this plan could be enhanced by timely demonstration projects, EPA funded two activities to demonstrate innovative, multi-purpose design of storm water facilities. The first demonstration is aimed at enhancing the capability of small detention basins to remove sediment-related pollutants. The second demonstration involves the retrofitting of existing, single-purpose detention basins to improve their ability to remove runoff pollutants and to control erosion-causing storm flows.

Both of these demonstration projects address maintenance, public education, and aesthetics as critical elements to their long-term success and acceptability by local officials, developers, and residents.

In response to severe channel erosion problems, the Illinois Department of Conservation has provided funding for a project to demonstrate effective, low-cost streambank stabilization using natural landscape materials. If successful, this demonstration will show property owners a way to protect their own streambank—creating an aesthetically pleasing landscape while preventing their property from literally being carried away by floodwaters.

Floodproofing

The most cost-effective method identified in the SCS study (USDA-SCS, 1987) to reduce flood damages in the Butterfield watershed was floodproofing of flood-prone properties. This solution, however, is dependent on acceptance by the private property owner; it is sometimes difficult to sell. The Committee, using a model created by IDOT/DWR, decided to promote the advantages of floodproofing through an educational open house at which local governments and agencies set up informational tables to inform homeowners. IDOT-DWR planned this event, which was attended by nearly 300 people. An interesting highlight of the *Floodproofing Open House* was the presentation by contractors of their floodproofing methods and equipment.

Homewood, a member community of the BCSC, is demonstrating its conviction to this element of the Action Plan. The village is preparing a pilot program under which eight flood-prone homes will be elevated, a maximum of 0.61 meters (2 feet), above the

established flood protection elevation. In addition to the house elevation program, 11 homes with basements or lower levels were identified as eligible for a special floodproofing program through the village.

Participating homeowners will be required to pay the first $1,500 towards the cost of elevating or floodproofing. The village will pay for the remaining portion. It is estimated that the total cost of elevating one home will be about $25,000. Having participated in the decision-making and planning process that produced the floodproofing recommendation, home-owners are anxious to have the work initiated.

Public Education

The Committee plans a series of educational efforts working with schools and libraries. The first of three planned videotapes is already completed. The Committee member working on this project convinced the local cable TV company to produce the first 15-minute video, which introduces the Committee and its work. The video was first broadcast to the concerned communities in February 1993.

The Butterfield Experience as a Model

The projects completed to date speak for themselves; some could be used in other watersheds, some are unique to this stream corridor. Beyond the projects, however, it is felt that there are four universally applicable lessons one can learn from the Butterfield experience. The first is that *streams do not respect geographic or political boundaries.* Storm water management must have the cooperation of all the watershed communities in order to solve problems. Demonstrating a united effort also makes it much easier to get outside help.

The second lesson is that *help is available.* While the state and federal agencies often receive criticism because of their regulatory responsibility, they are a resource of knowledgeable and dedicated people who really want to help solve problems. The residents of the Butterfield Creek watershed have been blessed with the help of many agencies. The agencies cannot do everything but, if the local governments are willing to work with what is possible, much can be accomplished.

The third lesson is that *it is important to know what can be done and what can't be done.* The communities and residents of the watershed had to accept that there would be no quick fix for the flooding problems. They had to recognize the need to help themselves and that it would take years of hard work to show any significant results.

Finally, *efforts to manage storm water can also provide a means to protect the environment and provide recreation when a holistic approach is used to find a solution.* A multi-objective approach is critical.

Butterfield Creek, like all streams, bears the imprint of its watershed. Every activity on the land draining into the stream impacts the stream's flow characteristics. Flooding, erosion, and environmental degradation are the creek's reaction to poor watershed planning. It is the hope of the BCSC that the waters of their creek will one day bear the positive imprint of the coordinated planning effort they are doing today.

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Watershed Management in Puget Sound: A Case Study

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Cooperative watershed management is key to cleaning up and protecting Puget Sound. The Puget Sound Water Quality Management Plan (Plan), approved as the first Comprehensive Conservation and Management Plan under the National Estuary Program in 1991, represents a comprehensive strategy, addressing a wide range of water quality problems. The Plan consists of 15 action programs designed to restore and protect the Sound and its many sub-watersheds. It was developed by a partnership of federal, state, local, and tribal governments, with extensive public outreach and involvement. A state agency created especially by the Washington State legislature in 1985 to develop, adopt and oversee the implementation of the Plan—the Puget Sound Water Quality Authority (Authority)—provided the leadership.

Implementation of the actions laid out in the Plan also depends upon strong partnerships. A notable example is the Puget Sound local watershed action program, the heart of controlling nonpoint pollution in the Sound. This is the heart, because the program is based on the premise that everyone contributes to the problem, and should be part of the solution, and because nonpoint source pollution is most effectively dealt with at the local level. Furthermore, the action program relies largely on voluntary compliance, rather than mandatory measures, through fostering community stewardship and public consensus on the most appropriate ways to reduce the harm from day-to-day activities in the local watershed.

The Puget Sound local watershed action program involves citizens, tribes, governments, and other stakeholders in the development of restoration and nonpoint source pollution prevention plans for targeted watersheds. It is a unique model, now five years old, that is constantly evolving as more plans are produced and implemented, and as we learn more about how to best control nonpoint pollution through this type of program. I will describe the framework and structure, the process, status, and the key issues confronting communities in the watershed as they move forward with implementing this part of the Plan.

The Problem

Puget Sound is a huge watershed, encompassing over 2,400 miles of shoreline, with over 10,000 rivers draining over 16,000 square miles of land. The Sound itself is 3,200 square miles. Essentially a fjord, with depths up to 930 feet, it also contains many shallow embayments, some of which still harbor a rich diversity of marine and wildlife. It is a complex estuarine ecosystem, with slow exchange of waters with the Pacific. As a result, pollutants running off the land tend to be trapped in the system for awhile, rather than flushed out right away. This physical and circulatory nature, combined with all the existing land uses and the accelerating rate of growth in the basin, has resulted in nonpoint source pollution being a significant threat to the health of Puget Sound. Storm water runoff, farm operations, timber and forestry practices, on-site septic systems, marinas and boats, household hazardous wastes, and various other activities, such as mining, are all contributors, the extent varying among all the sub-

watersheds. Degradation of the Sound adversely affects the economy as well. For example, Washington's shellfish harvest, worth $52 million in 1989, is seriously affected by nonpoint source pollution. Commercial and recreational shellfish beds are continually being downgraded and closed.

Selection of Watersheds

The Authority designed the local watershed action program to be a cooperative approach involving all stakeholders, but on a prioritized basis so as to make the best use of limited state and local resources. As directed by the Authority in the 1987 version of the Puget Sound plan, the 12 counties comprising the Sound basin ranked their local watersheds according to a specific set of criteria. The counties formed watershed ranking committees consisting of citizens, tribes, governmental entities, and interest groups to conduct the actual ranking. The Authority designed the five basic criteria to allow both restoration of damaged watersheds and protection of threatened ones:

1. Impaired or threatened beneficial uses, such as shellfish beds, fish habitat, and drinking water.
2. Likelihood of future intensified land use, such as development or logging.
3. Environmental factors such as limited flushing or soil type susceptible to further degradation.
4. Relatively more contaminants or greater harm to beneficial uses than other watersheds.
5. Likelihood of success.

Ranking committees could add other criteria, as suited their particular county. All the counties had ranked a total of 119 watersheds by January 1989.

Meanwhile, the state and local communities, also under the Plan, had selected 12 early action watersheds to get a head start on planning and to test the process. These watersheds were identified by mid-1987, with planning starting in 1988 under the guidance of a nonpoint rule adopted by the Authority early in 1988. This rule established the framework and process for both the watershed ranking and planning processes. The goals are preventing nonpoint source pollution, enhancing water quality, and protecting beneficial uses. The model was underway.

Model Features of the Local Watershed Action Program

The planning process steps are straightforward. The first step is characterization of the physical, biological, institutional, jurisdictional, and other characteristics of the watershed. The characterization is then used to define the extent of water quality and habitat problems resulting from nonpoint pollution, and subsequently serves as a basis for the goals and objectives of the action plan. Next, control strategies are developed for each type of nonpoint pollution problem, such as farming or forestry practices. These strategies encompass a combination of voluntary, educational and regulatory management approaches. An implementation strategy is prepared, including identification of responsible entities, costs, a timeline, a process for coordination with existing programs, and a plan for long-term financing. The plan then undergoes an extensive review and approval process. So what makes this program so unique, and worth learning from?

A number of unique features set this program apart.

1. *Local stakeholder committees develop the plan.* While a lead local agency, usually the planning department (public works departments and conservation districts have also been the lead), initiates the planning process through applying for a state grant (see item 4 below), the main entity responsible for developing the action plan is a watershed management committee comprised of all the stakeholders in the local watershed. This is a significant departure from the traditional planning approach where agencies develop plans with public comment at the end. The county (or city, if the watershed is within its boundaries) appoints the committee, which includes citizens, tribes, local agencies, federal and state agencies as appropriate, special- purpose districts, environmental groups, and business and industry. The purpose is to involve all affected parties in developing the most workable plan for their community, including those whose beneficial use is being impaired or potentially impaired and those who are associated with the various types of nonpoint pollution.

Thus the very foundation of this program is based in partnership and community stewardship. This program also helped gain recognition for the tribes as leaders in stewardship of the Sound's natural resources and technical experts in water quality, habitat, and fisheries issues. Additionally, the committee must develop a public involvement strategy for the planning process, to be carried out by the lead agency. All watershed residents are to have a chance to learn about and participate in cleaning up and protecting their bay or river.

2. *Committees most often use consensus to reach decisions.* The lead agency brings in experts in consensus-building to train watershed committees in making decisions by consensus. Each committee adopts ground rules for how they will proceed. Committees resort to voting if consensus cannot be reached, but the use of consensus is strongly encouraged. The intent is for differing factions to listen to and understand each other. Then they try to reach a common ground so the plan won't be stalled or blocked and it can be implemented to improve water quality.
3. *Signed statements of concurrence commit implementing entities to the plan.* The committee ensures commitment from all the responsible implementing parties through formal statements of concurrence. This is accomplished through circulation of the draft and final plans to all entities as early as possible in the process. Ideally, the representatives will already be on the committee and keeping their decision makers in the loop. They then submit letters commenting on the plan and stating their concurrence to their designated actions, within budget capabilities. The committee then formally adopts the plan, which the lead agency submits to the State Department of Ecology for final approval.
4. *The program is incentive-driven, not mandatory.* It is important to note that the state rule adopted by the Authority is not mandatory. The rule is only activated when a county or city applies for funding to develop the plan. The watershed program would not have been financially feasible without a special water quality fund set up by the State of Washington, called the Centennial Clean Water Fund, whose revenue source is a state cigarette tax. The legislature allocates $40 million a year in grants to local governments for water quality restoration and protection projects. Ten percent, or $4 million per year, goes toward nonpoint source control planning and implementation projects. So far, over $18 million has been invested in Puget Sound local watershed planning and implementation.
5. *Federal and state interagency teams provide direct technical assistance.* The Puget Sound Cooperative River Basin Team, funded through the U.S. Department of Agriculture, Soil Conservation Service (SCS) beginning in 1987, has prepared many of the characterization reports for the local watershed committees. The team consists of technical experts in relevant fields—biology, hydrology, wetlands, mapping—from SCS, the U.S. Forest Service, and several state resource agencies. This team has been such an invaluable resource that SCS has subsequently granted two 3-year extensions. This is the only river basin team to receive extensions. Additionally, the Department of Ecology leads an interagency technical assistance team, funded through the Puget Sound Plan, which consists of staff from all the state environmental and resource agencies and provides assistance to the committees. Finally, the state funds a water quality field agent team through both the Sea Grant and Cooperative Extension programs. These agents provide invaluable assistance in the field and on consensus-training and facilitation for the watershed committees.
6. *Committees determine the appropriate mix of management approaches for their community.* Committees have the option to develop three types of management approaches to controlling nonpoint pollution from identified sources. These approaches include education, voluntary actions, and regulation. The needs of the

communities vary from watershed to watershed. Generally, the more rural areas tend to rely more heavily on the educational and voluntary approaches, while the urbanized watersheds use a relatively higher percentage of regulatory tools, such as land-use ordinances. The 1988 nonpoint rule required committees to develop strategies for all the sources in the watershed, with very specific parameters. The rule has since been revised to allow committees to determine what kinds of controls work best in their community.

7. *All final action plans must contain implementation strategies.* A crucial element of the plan is a strong, sound strategy for implementation. This strategy has four components. Committees must identify for each action the responsible entity, the cost, a time frame, and a funding source. They must also identify long-term financing mechanisms, particularly at the local level, for ongoing implementation of the plan. Many Puget Sound local governments already have storm water utilities, for example. Some counties that have recent shellfish bed downgrades or closures are developing shellfish protection districts under a new law that allows them to assess fees to residents within the watershed. Conservation assessment districts, on-site septic maintenance districts, and bonds are other options being explored. Second, committees must include a process for coordinating with and integrating other planning and management programs; local comprehensive plans under the States Growth Management Act, local shoreline master plans, wetlands programs, groundwater management plans, and storm water programs are the most common examples. The intent here is to make the most efficient use of resources by using these programs as tools to help implement the plan and to use the watershed plan to help implement these programs. Third, the plan must include provisions for ongoing public involvement and participation in plan implementation activities, such as the adoption of ordinances. We strongly encourage the formation of implementation committees after the plans are approved to advise and assist the lead implementing agencies, and to perform a "watchdog" role. Finally, lead agencies must prepare annual evaluations of plan implementation, and conduct long-term monitoring programs, so that we can assess if and to what extent progress is being made in cleaning up Puget Sound.

Current Status

Eleven of the twelve Puget Sound counties are in various stages of watershed planning and implementation (Figure 1). The Puget Sound Plan goal states that each county shall be implementing at least three watershed action plans by 1996; this means a total of 36 plans. We are well on our way to meeting that goal. Fourteen watershed committees have completed plans that are being implemented in nine of the counties. Nineteen more committees are working on plans, with four more gearing up to start by the middle of 1993. Several counties or cities are expected to receive new planning grants in 1993. The Authority evaluated the early action watershed experience in 1990 and subsequently adopted a revised nonpoint rule in the fall of 1991. The rule streamlined the review and approval process and increased local flexibility.

How Well Is the Model Working?

Generally, the local watershed program is working. More plans are being produced and implemented each year since its inception, and we are starting to see water quality improvements in some watersheds. However, the pioneering nature of this program, involving sensitive issues of land use, resource management, changing lifestyles, and a nontraditional stakeholder planning process, has resulted in a number of challenges. The major issues facing the watershed program are sorting out participant roles during the planning process; building ownership of plans without reinventing the wheel; sustaining political will for plan implementation; obtaining and establishing adequate funding to carry out the plans; and integrating watershed planning with mandatory local growth management and other local resource-management programs.

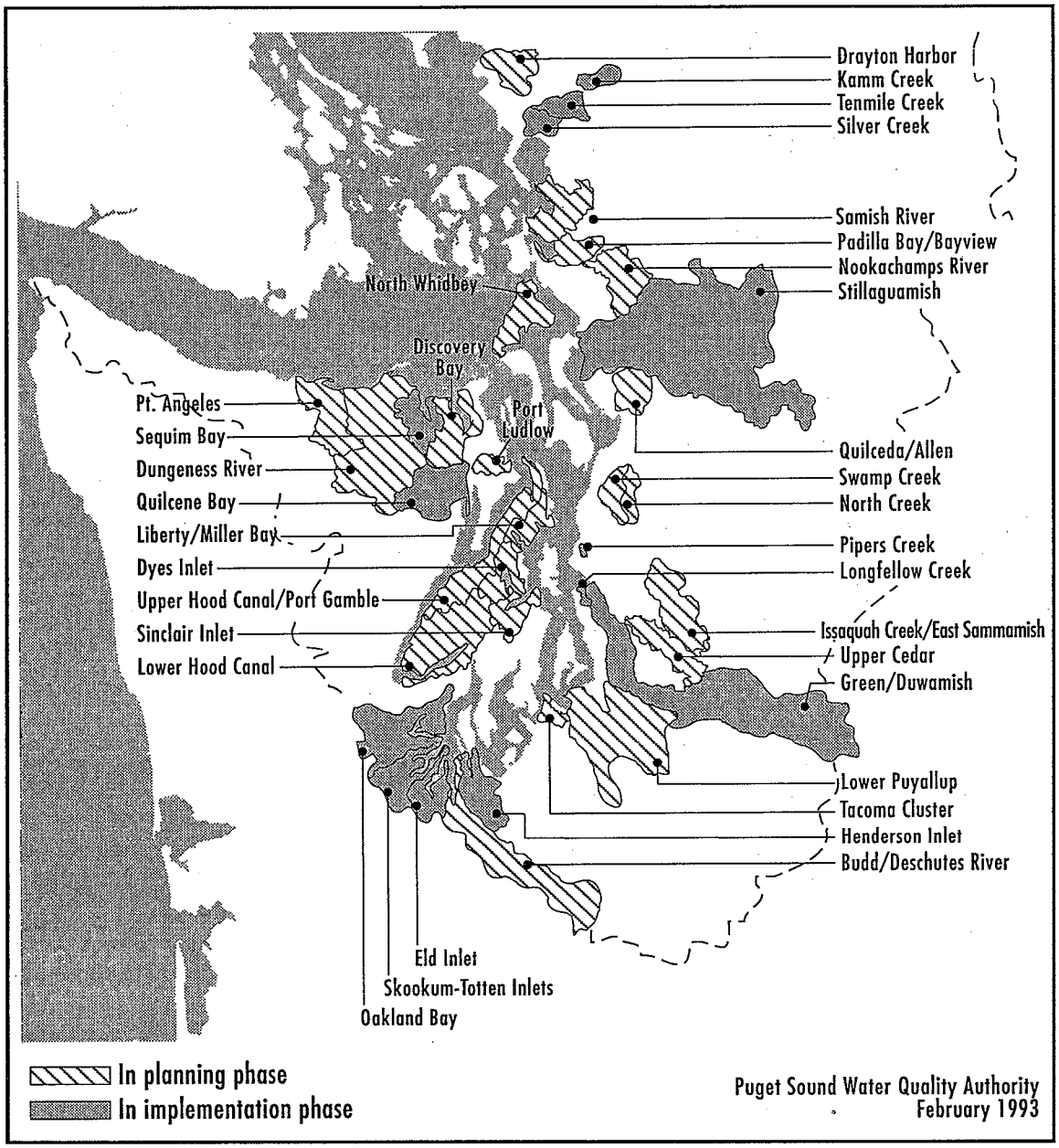

Figure 1. Watershed planning in the Puget Sound basin.

1. Counties appoint the committee members, facilitate the planning process, have representatives on the committee, and must concur with the plan actions for which they are responsible. However, the program is designed for the committee to be in the driver's seat, actually producing and adopting the plans. Some county officials have found this difficult. They would prefer instead to appoint citizens on a separate advisory committee or to approve the whole plan, not just the sections they are responsible for implementing.
2. Most counties are now on their second, third, or fourth plan. There is a delicate balance between taking time to educate committee members about nonpoint source impacts and solutions, in order to build trust and ownership, and discussing and deciding what control strategies and approaches will be in a particular plan. We are finding that, in order to help avoid committee boredom and

burnout, it is better to start discussions of possible solutions while they are learning about the problems, building upon plans already produced, and involving committees in educating their community.

3. Key factors in the planning process, which begin the process of building political will for implementation, are involving all stakeholders, obtaining early-buy in from decision makers, using consensus, obtaining concurrence from major implementers, and promoting community stewardship through strong public participation programs. Watershed plans overseen by implementation councils whose members act as advocates generally stand a better chance of being implemented. Ongoing public education and participation programs help keep the community aware of the plan's existence as a tool in helping to restore and protect their estuary or river.
4. Finding adequate funding for implementation of watershed action plans remains a constant struggle. This is a time when local governments are being asked to do more with less, and local resources are being directed towards mandatory growth management and storm water programs, among others. While many options for local funding mechanisms are available, it is difficult to convince watershed residents to pay even more annual fees, no matter how low or well-justified they might be.
5. Growth management and water-quantity planning efforts are competing with watershed planning in many areas. While the nonpoint rule requires committees to coordinate with and incorporate these and other resource-management programs, no reciprocal requirements exist. It is time to look at how these efforts can all be better integrated.

Conclusion

The Puget Sound local watershed action program, by its very nature, is the result of a cooperative partnership between the state, local and tribal governments, citizens, business, and public interest groups, and the federal government, all as stakeholders. Each plays a vital role. The state provides the program framework, financial incentives, and technical assistance. The local communities—not just the government agencies—actually develop and own the plan and are the prime implementers. Tribes are key participants. The federal government provides both financial and technical assistance and is responsible for controlling pollution on its lands. Consensus, concurrence by implementers, citizen and community stewardship, political will, local financing tools, and integration with growth management programs are proving to be critical factors in the success of these plans. However, the future success of this program is also ultimately dependent upon the ability of each of these entities to continue to work together, in the face of growing challenges, to protect the environmental and economic health of the local watersheds and the larger Puget Sound Basin.

Citizens Take the Lead: Elkhorn Creek Watershed Planning and Action Through Consensus

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The many tributary streams that create a river also have a major impact on its water quality. Yet with limited resources, state and federal water quality programs cannot manage entire watersheds and their tributary streams without the help of local property owners and local governments. Any successful program to restore them must awaken the stewardship values and harness the energies of the people whose daily lives are interwoven with these "hometown" streams.

As the watershed planning approach has advanced, through the efforts of agencies such as the Soil Conservation Service, so has the realization that improvement of water quality and quality of life is dependent on reaching a consensus about natural resources among those living and working in the watershed. Yet since the advent of the environmental movement, the relationship between property owners, citizen activists, and the government agencies that have the mandate and the resources to improve water quality has often been an uncomfortable and counterproductive one.

The experience of the Elkhorn Land and Historic Trust (Trust) illustrates a fairly successful consensus-building process for total resource planning within a watershed. It also shows how to build an effective, dynamic, and comfortable partnership between grass-roots citizen groups and government staff to carry out a watershed plan and provide ongoing stewardship for a local waterway. This presentation will describe the philosophy of the Trust, the total resource planning process for Elkhorn Creek, and the many public/private projects and initiatives that the plan has sparked throughout the watershed.

Elkhorn Creek waters the heart of Kentucky's world-renowned Bluegrass Region and has shaped the identity of its communities and people. The two forks and mainstem of the creek traverse 141 miles, drain a 500-square mile area encompassing four counties, and join the Kentucky River just north of the State Capitol. The path of the Elkhorn exemplifies the cultural, natural, and scenic resources of the Bluegrass Region and symbolizes its historic heritage. In the 1860 version of *Leaves of Grass*, Walt Whitman wrote of " . . . A Kentuckian, walking the Vale of the Elkhorn in my deerskin leggins. . . ."

In many ways, the experience of the Elkhorn today still recalls a century-old way of life. As Bluegrass residents shaped the agricultural and urban landscape, the corridor of the Elkhorn retained the last vestiges of Kentucky's lush native vegetation. Many historic structures, such as a working mill and a covered bridge, still remain. The creek has always been the primary water source for crop irrigation and stock watering, and was once one of the

top-rated small-mouth bass fisheries in the United States From the still pools held by mill dams, to the sleepy rural hamlets, to the dramatic palisades and whitewater beloved by canoeists and naturalists, the Elkhorn serves many needs.

However, as the creek was taken for granted and ignored over the years, water quality in the watershed became degraded. The problems are common: urban encroachment, increasing agricultural pressures, nonpoint runoff pollution and erosion, inadequate sewage treatment, decline in fisheries and wildlife habitat, loss of historic resources through neglect and redevelopment, illegal dumping, and growing conflicts between recreational users and property owners. These problems have slowly severed the traditional relationship of people to the creek. As a recent news article asked, "Would you want to be baptized in the Elkhorn?"

Formation of the Trust

In 1988 a group of concerned citizens and government staff formed a loose coalition called the Elkhorn Land and Historic Trust, which has been successful by following two essential philosophies:

- Build a consensus among the many user groups that depend upon the creek.
- Focus the considerable energies and resources of citizen volunteers and existing government programs on the creek.

In the beginning, the Trust was simply an informal gathering place for people who wanted to talk about the creek's problems and possible solutions. We were as inclusive as possible, constantly inviting knowledgeable citizens, property owners, and interested government staff to participate. We made a special effort to involve two types of government people. The first type are those whose agency's mission intersected with our goals, such as the county district conservation staff, local planners, Fish and Wildlife field personnel, and state water quality regulators. The second type are those who had a special personal relationship to the creek, such as the Scott County chief elected official, Judge Lusby, who fishes in the creek every day, and the director of the Kentucky department that awards community development grants, who lives on the creek. After all, government staff are regional residents too, and appealing to their professional and personal values is just as important as awakening stewardship values in citizens.

During this time we organized activities such as creek cleanups and encouraged many articles in local newspapers about conditions in the creek and the Trust's intentions. Once we had established a level of credibility and public awareness, we received a planning grant from the Kentucky Heritage Council, the state historic preservation office, with the help of their Rural Preservation Coordinator. This grant set a precedent for considering historic preservation in the wider context of natural resource planning.

The Elkhorn Action Plan

The Mayor of the Lexington-Fayette Urban County Government and the Judge-Executives of the other three counties in the watershed, Scott, Franklin, and Woodford, formed the Elkhorn Intercounty Planning Consortium to lead the planning effort. The Consortium was created by an Interlocal Agreement, which is sanctioned by a Kentucky law permitting local governments to coordinate their powers and authority. The agreement to protect and manage a shared natural resource was the first effort of its kind among local governments in Kentucky.

The elected officials established a planning steering committee, coordinated by the planners of each county, to build upon the partnerships and expertise identified by the Trust. The steering committee included many of the key players who would carry out the watershed action plan. With the help of a consultant, we met monthly for about a year. We examined a one mile-wide corridor centered on the creek and identified all known agricultural, natural, historic, tourism, and recreational resources, land use trends, and the water quality of the corridor. We held public meetings in communities along the creek to help identify important resources, threats to the creek, conflicts between uses, and hopes for future improvements.

Reaching Consensus

The public meetings confirmed that water quality was the problem uppermost in everyone's mind. The process also educated

people about the interrelationship between water quality and all other uses and values of the creek. This helped the participants understand the shared benefits of improving water quality and recognize their own personal responsibilities for carrying out the plan.

It was only with this comprehensive understanding of the interrelationship of resources and public values that we proposed consensus goals and a specific plan of action to meet them. The Action Plan was based on a common vision, but contains diverse solutions and approaches so that each person, community group, and government agency can choose those actions best suited to their values, talents, needs, and resources. The plan also recommends an ongoing agenda for the local elected officials acting together in the Intercounty Consortium.

Key partners throughout the planning process have been the Soil Conservation Service and the local Soil and Water Conservation Districts. Working as a team, these agencies provide technical assistance to land users and offer an effective program delivery service to farmers. To help address natural resource issues, the Soil Conservation Service prepared a Total Resource Management Plan for the Elkhorn Watershed. Integral to this plan are the local concerns and interests expressed in the series of public meetings sponsored by the Trust.

Results

These planning efforts cemented partnerships and spun-off energies to bring about results at the local, regional, and statewide levels. Local and regional benefits include the following projects.

- *Scott County Comprehensive Plan.* Led by a Citizen Advisory Committee, the new plan set policy for no further fill or development in the floodplain of Elkhorn Creek within the City of Georgetown and the county. It created a greenspace and recreation network plan following the creek.
- *Agricultural Water Quality Cost-Sharing Program.* This innovative, locally-funded cost-sharing program helps farmers improve and protect water quality by excluding livestock from riparian areas. This is a voluntary program administered by the Scott County Conservation District, with 75 percent funding provided by the Scott County Fiscal Court for projects such as fencing and development of alternate water sources.
- *Best management practices demonstration project.* The EPA has funded this project to improve water quality and wildlife habitat by demonstrating new technology and methods for restricting livestock access to sensitive riparian areas. The project includes monitoring to document changes in water quality and habitat. It is also intended to encourage participation in the Agricultural Water Quality Cost-Sharing Program by demonstrating the feasibility and benefits of the improvements.
- *Elkhorn environmental education center.* A hands-on environmental education program for at-risk high school students was created. Planning has begun for an environmental center and historical museum at a creekside park near a new elementary school. The project has been funded by a state Community Rivers and Streams Grant in cooperation with the Scott County School Board, county and city governments, and the Scott County Education Foundation, a nonprofit citizen/business organization.
- *Creekside woodlands demonstration project.* This project will include a landscape plan to restore and manage both degraded and natural riparian vegetation at a city park. A handbook will be developed for private and public property owners on how to recognize typical creekside species and best manage the vegetation for erosion control and natural habitat value. Funds will be provided by an Urban Forestry Grant, in cooperation with the Scott County Parks and Recreation Department, Planning Commission, and Singer Gardens (a private nursery).
- *Creek cleanup program.* To date, five major creek bank dumps and several dumps in sinkholes near the creek have been cleaned up. These efforts have been coordinated by county Solid Waste Management

Directors using county road equipment, prisoners, parks departments, a commercial canoe livery, and many volunteers. Two of the dumps were near county boundaries and were cleaned up through cooperation between local governments.

- *Public creek access parks.* The Elkhorn Action Plan proposed a network of parks to better provide for and manage public access to the creek and reduce trespassing on private land. Four public access points have been secured and developed through donations, local funds, and Land and Water Conservation grants. Negotiations are underway for four additional sites.

Sharing Leadership and Responsibility

The Elkhorn Trust itself has not been the instigator of many of these activities and rarely takes credit for them. Part of our success lies in relinquishing control of the Action Plan and its results. The planning process sparked ideas, identified resources, and moved minds in the same directions; creative individuals have done the rest, by finding ways to focus their agencies and organizations on the part of the problem they cared about the most. This approach has widened the sense of "ownership" of Elkhorn Creek, which is a crucial step in building a lasting stewardship effort that has strength in diversity of involvement.

Sharing leadership for improvements in the watershed has helped in many ways. For example, one of the Trust's major challenges has been in resolving property owner and recreational conflicts. Property owners along the prime canoeing route are suspicious of the Trust because of commercial recreational interests represented in our membership, despite scrupulous efforts by the latter to avoid conflict of interest. However, the Soil Conservation Service staff for the region and county has a good relationship with these property owners, and continues to work with them to solve water quality problems, which is our key goal.

New Directions at the State Level

The successful example of the Elkhorn Trust and other groups like it in Kentucky has led to significant state-level initiatives for water resource stewardship. In 1992 the Kentucky General Assembly funded the *Community Rivers and Streams Program*, a seed grant program to encourage similar citizen efforts throughout the state. These funds are awarded to local governments, and the selection criteria favor comprehensive resource planning through multigovernment partnerships with citizen groups. It is clearly a popular program. Fifty-four local governments, 14 citizen water resource groups, and 30 additional government and citizen organizations formed partnerships to participate in the first year grant applications, competing for only 10 grant awards of $5,000 each. The program has leveraged over $163,500 in local matching funds and in-kind assistance.

As an exciting next step, we have recently formed the *Kentucky Waterways Alliance*, a statewide coalition of citizen stewardship groups for rivers, streams, lakes, and underground waterways. The Alliance will help build and strengthen local citizen groups like the Trust by providing financial and technical resources, networks, advocacy, and education. Through these state-wide initiatives, we hope that the model of total resource watershed planning, consensus-building, and partnerships between citizens and governments will sweep Kentucky and continue to transform the way we care for our water resources.

Partnerships for Regional Watershed Planning: The ORSANCO Experience

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For approximately 2 years, water quality program managers and technical experts from various state and federal agencies and the Cooperative Extension Service have been meeting on a regular basis to discuss water quality issues, consider new technology, and explore opportunities for greater cooperation and coordination of their respective programs and activities.

The timing of this initiative coincided with passage of the 1990 Farm Bill and subsequent recognition on the part of the U.S. Department of Agriculture (USDA) agencies of the need to do more about agricultural nonpoint source pollution. USDA leaders at the state level made overtures to state agencies with both regulatory authority and technical and financial support capabilities.

Membership on the Kentucky Water Interagency Coordinating Committee (KWICC) originally consisted of representatives from the Divisions of Water and Conservation in the Natural Resources and Environmental Protection Cabinet; the Kentucky and U.S. Geological Survey; Soil Conservation Service and Agricultural Stabilization and Conservation Service; the Kentucky Department of Agriculture; the University of Kentucky; Kentucky State University, an 1890 land grant institution; and the Cooperative Extension Service. Later, a representative from the Kentucky Farm Bureau Federation was added.

Among the many projects on which the representatives of these agencies and the Farm Bureau have worked together or consulted each other on over the past 2 years are refining the watershed planning process; designing a geographical information system; compiling an agricultural best management practices (BMP) manual, as well as a state pesticide management plan; developing an agricultural chemical collection and container recycling program; and evaluating constructed wetlands as a component of animal waste-management systems.

These projects are in various stages of completion and the real impact on them by KWICC has varied. However, the fact that they were discussed by such a group during sensitive stages of development reveals a new openness and a willingness on the part of these agencies to work together for the betterment of agriculture and the environment. Still, those who were responsible for bringing this diverse group together recognized a major void in the structure and composition of the committee, and that was a noticeable absence of those individuals who actually make policy at the state level. Although the members of KWICC represent agencies and other entities that are deeply concerned and involved in water quality issues and programs, they are not personally in a position to push for legislation, to make budget recommendations, and to lobby federal legislators and agency administrators.

During the interim period since the formation of KWICC, Kentucky voters elected a new Governor and a new Commissioner of Agriculture. And, the membership of the Kentucky Farm Bureau also elected a new board. These were enlightened and forward-looking individuals who understood the need to get out front on many of

the important environmental issues—to assume a leadership role rather than wait for the federal government to dictate an agenda.

At the urging of Farm Bureau President Bill Sprague, Commissioner of Agriculture Ed Logsdon, and other influential agricultural leaders, Governor Brereton Jones, on February 5, 1993, issued an Executive Order creating the Kentucky Agricultural Water Quality Policy Advisory Committee. The membership of this committee currently consists of the Governor, who serves as Chairman; the Commissioner of Agriculture, Vice Chairman; the Dean of the University of Kentucky College of Agriculture; the Deputy Secretary of the National Resources and Environmental Protection Cabinet; and the First Vice President of the Kentucky Farm Bureau.

The principal charge of this committee is to develop a water quality model of excellence for the Commonwealth of Kentucky, an embodiment of goals, policies, and directives that encourage and assist landowners; private business concerns; and local, state, and federal entities to assess water quality problems, identify best management practices, and marshal the resources to implement those practices. Other functions of the Agricultural Water Quality Policy Advisory Committee will be to assure interagency cooperation, determine priorities, and secure whatever additional authorities and funding may be needed to achieve the committee's goals and objectives.

The appropriate federal agencies with offices in the state will also be invited to the table and given an opportunity to participate in the deliberations of the committee.

With this last component of the federal/state partnership in place, Kentucky is poised to make great strides in the environmentally crucial areas of erosion control, waste management, and water quality improvement.

Watershed Protection— A Private/Public Issue

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Philadelphia Suburban Water Company (PSWC) is a private, investor-owned water utility which serves a population of over 800,000 people in the suburbs north and west of Philadelphia, PA. The company's service territory covers 379 square miles in parts of Bucks, Montgomery, Chester, and Delaware Counties.

Average send-out is about 89.5 million gallons per day, which is obtained from a variety of sources. Four surface water treatment plants supply about 75 percent of average demand, while the balance is derived from 50 wells and a ground water-fed reservoir. Surface water is withdrawn from the Schuylkill River and four smaller streams: Pickering Creek, Perkiomen Creek, Crum Creek, and Neshaminy Creek.

PSWC's first surface water treatment plants were built over a century ago on pristine rural streams. Supply was expanded by the construction of reservoirs in areas which were rural in character at the time. The company now owns and operates six impoundments, including the Green Lane and Springton reservoirs.

In 1895, the Pickering Creek treatment plant was built at the confluence of the Pickering Creek with the Schuylkill River. At the time, the Schuylkill was fouled with spoil from coal mines and with inadequately treated wastewater discharges. It was considered unsuitable as a raw water source. Construction and upgrading of sewer plants, elimination of discharges from heavy industry, and an extensive dredging project undertaken by the Commonwealth of Pennsylvania and the Army Corps of Engineers between 1952 and 1964 succeeded in bringing about dramatic improvements in the Schuylkill. Today, it is a major source of supply for the Pickering plant. The restoration of the Schuylkill River is a testament to what can be accomplished by concerted effort on the part of the public sector.

As a private-sector company, PSWC has contributed to the protection and enhancement of water quality through its own programs. For decades, PSWC has maintained an active watershed patrol program. The function of this program has evolved over the years with the development of the watersheds, and the simultaneous implementation of pollution control and abatement measures under federal and state law. Originally designed to prevent obvious contamination of the watersheds by direct discharges from point sources and poor farming practices, the program has evolved in scope and sophistication.

Replacement of farms with suburban developments, enforcement of erosion and sedimentation control measures by county soil conservation districts, and effective public education have produced marked improvements in the watersheds. At the same time, development has increased the volume of road runoff and sewage discharges that contribute to normal streamflows, particularly on the Neshaminy watershed.

In the region which PSWC serves, it has not been reasonable or defensible to rely heavily on ownership of watershed lands to secure a good quality raw water supply. Furthermore, the company lacks specific enforcement powers to address actual or potential contamination. Cooperation with local government and with state and federal agencies is essential in any effort to protect the quality of raw water supplies for human

needs and to preserve the aquatic environment.

The routine work of PSWC's Environmental Specialists now involves dealing with everything from an occasional oil spill to sagging silt fences, from reservoir eutrophication and algae blooms to masses of Asiatic clams. In these activities, they may work closely with local code enforcement officers, emergency response teams, county soil conservation districts, state Water Quality Specialists and occasionally with the U.S. Environmental Protection Agency (EPA), who can now bring an impressive array of resources to bear on a 50-gallon fuel oil spill, a leaking underground tank, or an unpermitted residential greywater discharge pipe.

Occasionally—and fortunately it is only occasionally—PSWC is faced with a serious threat to the company's water resources. The successful resolution of these problems usually involves a partnership between our private water utility and regulators, enforcement agencies, or governmental bodies in the public sector.

Ground-Water Contamination

Ground-water protection within the PSWC territory continues to be a major challenge. In the late 1970s, volatile organic contaminants were detected in several ground-water sources. Long before the enactment of regulations under the Safe Drinking Water Act, PSWC addressed these problems with the installation of air strippers at four facilities. The Upper Merion Reservoir (UMR) was the largest and the first source treated.

The UMR is a former limestone quarry which was converted in 1969 into a reservoir and water supply source. A few years later, a trash hauler purchased nearby land and commenced some questionable activities on the property in 1975. Two years later, the Pennsylvania Department of Environmental Resources (PaDER) uncovered evidence of illegal disposal of liquid wastes into an abandoned well on the property, about 2,000 feet from the UMR. PSWC subsequently discovered trace contaminants in the UMR and, in cooperation with PaDER, conducted a thorough reconnaissance survey of the area. This search turned up a second potential source of contamination.

Unfortunately, although underground disposal of wastes ceased at both sites, enforcement actions languished and business continued as usual at both sites. EPA assumed jurisdiction over both sites under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA, better known as Superfund), but site investigation and legal maneuvering continued for more than a decade. EPA refused to acknowledge the contribution of PSWC's own response action, or to require reimbursement of the water company's treatment costs from the Potentially Responsible Parties (PRPs).

Obviously, cooperation between PSWC, PaDER, and EPA was not always smooth. Eventually, in 1989, PSWC filed a separate legal action against the PRPs under Section 107 of CERCLA, and obtained a partial settlement for its response costs. At the same time, EPA took independent legal action under section 106 of CERCLA. The water company, PaDER, and EPA began working in concert again, and the PRPs were forced to move expeditiously on remediation. Today, the former landfill area has been capped and an extensive ground water clean-up operation is underway. Progress is being made on cleanup at the second site. These cases stand as an example of what can be accomplished when Superfund finally moves from the morass of investigation and litigation into purposeful cleanup.

Crum Creek—Impacts of Major Earth Disturbances

The Crum Creek watershed encompasses 28.5 square miles upstream of PSWC's treatment plant. The smaller Crum Creek Reservoir was built in 1918. It impounds water from a 7.5-square-mile drainage area and also receives releases from the much larger Springton Reservoir upstream. The Springton Reservoir was built in 1931, covers 391 acres, and has a capacity of approximately 3.5 billion gallons.

The reservoirs in this system are more prone to impact from localized problems because of the small drainage area. One such localized problem was construction of an Interstate highway through the stream valley. During the spring of 1988, construction of Interstate 476 began in earnest. Both the local Soil Conservation District and

PaDER tried to be vigilant in requiring and inspecting control measures. An independent "Environmental Monitor" was hired to look over the entire highway project. Despite these measures, however, an estimated 15,000 cubic yards of material were deposited in the Crum Creek Reservoir between 1988 and 1990, based on soundings. The water company is prepared to dredge this material out over a number of years, but has so far been denied compensation from the state highway department or its contractors.

Neshaminy Creek—Response to In-Stream Contamination

In our modern society, which continues to generate large volumes of problem wastes, well-meaning regulation can sometimes have unintended consequences. To provide for the proper disposal of hazardous wastes, the Commonwealth of Pennsylvania has permitted four Hazardous Waste Management Facilities throughout the state but no disposal sites. One of the management facilities is located on the Neshaminy Creek watershed and discharges treated wastewater to the Hatfield wastewater plant 28 miles upstream of the intake at PSWC's Neshaminy Falls water plant. The plant is the smallest of PSWC's surface water plants, with an average send-out of about 9 million gallons per day. The raw water source is a stream draining a 215-square-mile, heavily developed suburban watershed.

PSWC recognizes that the state must have proper facilities for handling of hazardous wastes, but has always been uneasy about this particular facility. The facility has caused special problems with wastes and odors in the past, and PSWC has devoted a significant portion of its limited research resources to develop and implement special analytical techniques to monitor for unusual contaminants from it.

Over about 20 days, from January 31 through February 20, 1992, a very serious odor event occurred at the Neshaminy plant. Plant operators first detected an unusual "sweet" chemical odor in the water in the early morning hours of January 31. Within 12 hours, the source of the odor was traced to the Hatfield wastewater plant. Operators of this plant and the waste management facility were notified. An extensive battery of tests was performed to identify the cause of the odor, and extraordinary treatment measures were taken to attempt to remove it. No contamination was discernible from the tests of the treated water, but the intensity of the odor continued to increase. By Sunday, February 9, customer complaints were increasing, and a deluge arrived on Monday, February 10.

Meanwhile, PSWC's Research Lab was focusing on traces of unidentified compounds which showed up in its most sensitive analyses of wastewater samples from the Hatfield wastewater plant and a few stream samples. Information was shared with PaDER laboratories in Harrisburg. PaDER chemists reported that the incident bore similarities to a case which had occurred in western Pennsylvania in August 1989. In this earlier incident, a wastewater plant discharge containing small amounts of industrial waste had caused taste and odor complaints along the Ohio River as far south as Cincinnati. The specific chemical compound responsible had never been identified.

Some extraordinary analytical sleuthing by PSWC's Research Laboratory and by Monell Chemical Senses Center in Philadelphia, successfully found the signature of the compound responsible, divined its chemical identity, and synthesized a minute quantity in order to confirm its properties and to determine the quantity which had been present during the incident on the Neshaminy Creek.

The waste management facility had received for treatment about 30,000 gallons of wastewater characterized as nonhazardous but which contained about 1 milligram/liter (part per million) of the odor-causing agent. Over a 10-day period, about 20,000 gallons of water from this batch of waste was discharged to the Hatfield sewer plant. The discharge probably contained about 75 grams (less than 3 ounces) of the chemical compound. This was subsequently diluted in a flow of about 4 million gallons/day from the wastewater plant, and then further diluted in the Neshaminy Creek. The total amount of the chemical in the raw water withdrawn at the Neshaminy plant during this entire incident was probably less than 5 grams. The concentration of the compound in the treated water leaving the Neshaminy Plant was less than 10 parts per *trillion.*

At the height of the incident, the discharge pipe from the waste management facility was plugged by the sewer plant operators, and the discharge valve was

padlocked. PaDER investigated operations at the waste management facility, and both PaDER and EPA examined the sewer plant's Municipal Industrial Pretreatment program. PSWC recovered damages from the hazardous waste management facility and sought major operational changes and restrictions on the waste management facility as a precondition for continued discharges to the sewer plant.

Clearly, more still needs to be done in the area of public/private cooperation in dealing with watershed issues. There are often serious lapses in communication between state water quality investigators and water suppliers. Significant policy issues remain to be addressed. For example, there are a number of hazardous waste management facilities throughout the country which discharge to wastewater plants above water supply intakes. These facilities rarely have more than a very superficial knowledge of the chemical composition of the wastes which they accept for treatment. If the Waste Acceptance Documentation were required to disclose the location of the waste management facility relative to a water supply intake, generators, who best understand the nature and composition of their waste, would share the responsibility for ensuring against adverse consequences of improper disposal.

Green Lane Reservoir—Protecting a Resource

PSWC's Green Lane Reservoir was built in 1956 and impounds 4.4 billion gallons from a 71-square-mile drainage area of the Perkiomen Creek. The resulting lake covers 814 acres, and releases from this lake augment stream flow while supplying PSWC's intakes 18 miles downstream.

One of PSWC's current concerns is the prospect of an invasion of zebra mussels into the company's reservoirs. Recreational boating is permitted at the Green Lane Reservoir and is restricted to electric or manually powered craft. In 1959, as a gesture of goodwill to the local community, PSWC opened its Green Lane Reservoir to limited boating and fishing. In 1983, as an alternative to selling excess land around the reservoir for development, PSWC sold 1,087 acres to Montgomery County (PA) for use as a public park. PSWC retained the reservoir and 514 acres of adjacent land, but granted the county an easement to use the reservoir for limited recreational purposes. In 1987, farmland around the reservoir was enrolled in the U.S. Department of Agriculture Conservation Reserve Program upon mutual agreement with existing leaseholders.

Beginning May 1, 1993, boating restrictions will allow only boats that are stored on site to be used in this reservoir. Racks are currently being constructed for boat storage. Following a 10-day quarantine and subsequent inspection, boats will be allowed on the reservoir. PSWC has worked closely with Montgomery County to develop a program that allows limited boating on the reservoir, but minimizes the possibility of boaters introducing the zebra mussel. In order to minimize the effect, PSWC has shared expenses with the County to allow construction of boat racks and the purchase of additional rental boats.

Summary and Conclusions

An analysis of the experiences reported in this paper indicates that there is an inverse relationship between the hierarchical level of a regulatory agency and the level of cooperation, understanding, and productivity towards resolution of watershed issues. Further, it becomes clear that the existing regulations are inadequate to efficiently resolve conflicting water uses. The protection of human health and safety must be recognized as the highest priority use for water and clearly designated as such in legislation. The evolutionary trend towards basin and sub-basin management will be severely hampered without a mechanism that recognizes and resolves conflicting use issues.

The Patuxent Estuary Demonstration Project: Partnerships Restoring the Patuxent River

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The Patuxent Demonstration Project is the latest phase of an ongoing partnership between federal, state, and local governments that have been working together since the early 1970s to restore the water quality and living resources of Maryland's Patuxent River and its estuary.

Recognizing the importance of this effort and the value of Maryland's experience in the Patuxent watershed to others facing similar problems, the U.S. Environmental Protection Agency (EPA) granted Maryland $3.5 million to support this $5.3 million Demonstration Project. The Project's primary goal is to expand the Patuxent restoration effort to include the application of land management in improving water quality.

History

The Patuxent River is one of Maryland's major tributaries to the Chesapeake Bay. Located in the most rapidly developing region of the state, between the Baltimore and Washington metropolitan areas, the watershed's streams, rivers and the Patuxent estuary are subject to most of the same water quality problems currently facing developing regions throughout the world. The symptoms of eutrophication—algae blooms, decreasing water clarity, low dissolved oxygen, and declining health of important fisheries—are particularly evident in the Patuxent estuary and have been the focus of an ambitious nutrient pollution reduction effort since the late 1970s.

The 1970s: Early Concerns and Interjurisdictional Controversies

A comprehensive review of the historical water quality data for the period 1936-1976 (Mihursky and Boynton, 1978) showed trends of increased nutrient concentrations, increased algal growth, decreased water column transparency, and extended oxygen depletion in the bottom waters of the lower Patuxent estuary. These changes in Patuxent water quality were ultimately expressed in the declining health of living resources. A significant loss of submerged aquatic vegetation was reported, with an associated loss of food sources and vital habitat. Harvests of commercially important species such as striped bass and oysters were reported to have declined dramatically.

In an effort to find solutions to these problems, Maryland initiated an extensive review of the existing water quality data for the Patuxent, and an intensive monitoring program to collect additional information to support development of a water quality model of the Patuxent estuary. Results of the modeling analysis indicated that a point source (PS) phosphorus control policy would result in the greatest water quality benefits in the Patuxent. However, the analysis was the subject of considerable controversy; this

controversy even extended to legal action. The three counties of south-ern Maryland, where the river plays a larger role in defining lifestyles and livelihoods, sued EPA and the state in 1977 over the state's water quality management plan. The southern counties challenged the plan pri-marily because it did not include a strategy for nitrogen removal; the legal suit delayed expansion of an upstream sewage treatment plant.

The Patuxent Charette

In an effort to resolve disagreements about the nutrient removal strategy for the Patuxent, the state convened an intensive arbitration workshop in December 1981. Referred to as the *Charette*, the workshop involved representatives from the local, state, and federal governments, utility agencies, and other user groups. The Charette resulted in agreement on and the adoption of water quality, fisheries productivity, aesthetic, and recreational goals for the Patuxent system.

The Charette successfully reached a consensus for action that included:

- Acceptance of the water quality model results.
- Agreement that a watershed-wide nutrient control strategy was needed.
- Agreement that both phosphorus and nitrogen would be reduced.
- Recognition that additional research and modeling were needed.

It was also agreed that further monitoring was necessary to track progress. The Charette marked the beginning of a more cooperative approach to watershed protection.

Patuxent Nutrient Reduction Goals

With the 1981 consensus as a foundation for management actions, the 208 Water Quality Management Plan for the Patuxent River Basin was developed. The plan outlined a broad approach for improving water quality in the estuary by:

- Formally adopting specific goals for nitrogen and phosphorus control from point and nonpoint sources.
- Proposing that efforts to protect the river must go forward based on the best available information at that time.
- Calling for an intensive monitoring, research, and modeling effort to improve understanding of the river.
- Providing for adjustment of the management strategy as new information becomes available.

Following adoption of the Water Quality Management Plan, the State of Maryland developed and initiated the Patuxent Nutrient Control Strategy (OEP, 1983). The Patuxent Strategy identified specific nitrogen and phosphorus reduction goals as follows:

- PS phosphorus loads were to be reduced to 420 pounds per day.
- PS nitrogen loads were to be reduced to 4,040 pounds per day.
- Nonpoint-source (NPS) nitrogen loads were to be reduced by 2000 pounds per day from the 1981 levels.

It was expected that phosphorus NPS loads would be reduced through control of sediment runoff to be achieved under agricultural and storm water cost-share programs. The Strategy also called for the continuation of a comprehensive monitoring, modeling, and research program to reduce scientific uncertainty and to confirm the response of the Patuxent system to management actions.

The Patuxent River Commission

In 1980, the Patuxent River Commission was established by state legislation. The Commission, with representatives from the seven counties in the watershed and the four state agencies with water-quality- and resource-protection-related responsibilities, was established to provide coordination to the restoration effort. The Commission's role in the Demonstration Project is described below.

The Patuxent Policy Plan

Concurrent with the development of the Patuxent Nutrient Control Strategy, the Patuxent River Commission developed the *Patuxent River Policy Plan: A Land Management Strategy* (1984). Following an extensive series of public meetings, the Policy Plan was adopted by resolution in the Maryland General Assembly and the seven county governments in 1984. The Policy Plan provides guidance to state and local governments in making land use management decisions and controlling water pollution. This document represented one of the first attempts to incorporate water quality objectives in a cooperative state- and local-government-approved land use management program. It also served as a

conceptual basis for Maryland's Chesapeake Bay Critical Area Management Act of 1984.

Chesapeake Bay Restoration Effort

Maryland's Patuxent restoration effort has served as an example for the Chesapeake Bay restoration effort in many other ways as well. The States of Maryland, Virginia, Pennsylvania, and the District of Columbia, as well as EPA, signed the initial Chesapeake Bay Agreement in 1983. The scope of the Bay Agreement was expanded in 1987 to include, among other things, a commitment to reduce overall nutrient loading to the Chesapeake Bay by 40 percent. Each participating jurisdiction also agreed to develop a nutrient reduction strategy designed to achieve the 40 percent goal.

In 1992, following an extensive technical evaluation of the nutrient reduction strategies developed for the 1987 Bay Agreement, a number of additional commitments were added to the 1987 Bay Agreement. Among those were the commitment to develop and begin implementation of specific nutrient management plans for ten major Bay tributaries, including the Patuxent.

The Patuxent Demonstration Project

By 1991, substantial progress had been made in controlling PS; federal, state, and local investments in upgrades of sewage treatment plants for removal of nitrogen and phosphorus had brought attainment of Patuxent PS nutrient goals. Yet NPS nutrient pollution, particularly NPS nitrogen loads, still exceeded target levels.

Project Goals and Objectives

The Patuxent Demonstration Project has provided an opportunity for the State of Maryland to bring together all of these contributing efforts into a single, comprehensive restoration strategy. The Project is designed to enhance state and local cooperation in refining and implementing a water quality management strategy for the Patuxent watershed, based on controlling PS and NPS of pollution, that includes land and resource planning as essential components.

In pursuit of this goal, the Project has three primary objectives:

1. To document the linkages between land management and NPS pollution control in the Patuxent watershed, and water quality and living resources conditions in the Patuxent estuary, in order to provide sound technical bases for future land-use and water quality management decisions.
2. To improve the coordination of policy-making processes in the numerous jurisdictions composing the Patuxent watershed so that meaningful watershed management actions may result.
3. To demonstrate the effectiveness of various innovative techniques for reducing NPS pollution.

Project Components and Approach

The Project has six major components:

1. Establishment of an organizational structure for the coordination of planning, technical analysis, and implementation of control measures.
2. Identification of issues, environmental goals, and management options available to achieve those goals.
3. Completion of a comprehensive data base and linked watershed and tidal water quality models. These models will predict nutrient and sediment loads to the estuary, as well as the water quality response of the estuary to proposed management actions.
4. Provision of $1.5 million of federal funds for the implementation of projects to demonstrate new and innovative NPS pollution control measures.
5. Development of water quality and resource management guidance for state and local governments to document the results of the Project and define the management options and recommended strategy.
6. Based on the guidance document, development of a formal state and local government Patuxent Agreement analogous to the interstate Chesapeake Bay Agreement. This Agreement will include goals, time frames, and commitments and will provide the basis for comprehensive improvement of water quality and living resources conditions.

The Project's Organizational Structure

The Patuxent River Commission's Role

In 1991, the Patuxent River Commission was charged with overseeing the Demonstration Project. The Commission gives general guidance and oversight, provides a forum for limited public participation, and approves recommended decisions about which demonstration implementation proposals receive Project funding.

To date, the Commission's limited resources and authority have constrained its ability to provide meaningful direction either for the overall Patuxent effort or for the Demonstration Project. Only three of the Commission's seven county representatives hold positions within their county government that allow them to speak for, or make commitments on behalf of, the county they represent. The other county representatives include, for example, a state senator and an environmental activist.

Although not stated as an explicit Project goal, many people involved with the Patuxent restoration effort hope that giving the Commission authority to oversee the Project will increase its effectiveness in coordinating efforts to protect the River.

The Project's Partners

The Project's local and state partners include the following:

- The seven county governments in the watershed: Anne Arundel, Calvert, Charles, Howard, Montgomery, Prince George's, and St. Mary's.
- The seven counties' soil conservation districts.
- The Tri-County Council for Southern Maryland, which represents the three southern Maryland counties.
- The municipalities of Laurel and Bowie, which are in Prince George's County.
- The Maryland Office of Planning; the Maryland Departments of Environment, Natural Resources, and Agriculture; and the Governor's Office.

As noted above, EPA provided substantial funding for the Project; however, EPA has not played an active role in Project activities to date.

Each of these partners has representatives on the Project's three standing committees—Technical, Planning, and Implementation. These committees meet monthly on average; their roles and activities are discussed briefly below.

Technical Committee

Most, though not all, of the technical work for the Project is being done by the State. The Technical Committee oversees the relevant monitoring, modeling, and research efforts. It is charged with reviewing and, when necessary, guiding the state's technical work to ensure that the results are acceptable to the local partners. Its activities include:

- Reviewing and providing input into the watershed models, and conducting other technical analyses for the Project.
- Providing guidance on water quality monitoring.
- Recommending development of a regular *"State of the Patuxent"* report.
- Collecting and disseminating information on the effectiveness of urban and agricultural best management practices (BMPs).

Planning Committee

This committee provides a comprehensive planning approach to the Project, designs management scenarios, and develops appropriate strategies for the counties and the watershed as a whole. Its activities include:

- Defining state and local NPS issues and priorities.
- Cataloging and reviewing NPS management tools.
- Developing management scenarios and supporting information.
- Providing guidance to and interacting with the Technical Committee on modeling issues.
- Developing the Guidance Document, including its recommendations for NPS management.
- Developing the Patuxent Agreement.

Implementation Committee

This committee is charged with selecting demonstration implementation projects throughout the watershed to recommend to

the Patuxent River Commission for Demonstration Project funding. It is also responsible for gathering information about existing and planned NPS control implementation efforts. Its activities include the following:

- Developing criteria for recommending implementation projects to receive support from the Project's $1.5 million implementation fund.
- Designing a process for soliciting and reviewing proposals for implementation projects.
- Recommending implementation projects to the Commission for funding.
- Producing an inventory of BMPs for use in the watershed model and other technical analyses.

Results of the Project

Working through these committees, the Project's results will include:

1. Determination of Baseline Pollution Loads

Baseline nutrient loading and water quality conditions, derived from the state's watershed and water quality models, were summarized for the Project participants. Nutrient loading reduction goals were compared with current estimates of loading from the major PS and NPS in order to define progress toward meeting the goals. In addition, loading was estimated using current growth projections to the year 2000 to begin to identify the relative benefits of different options for further nutrient control measures.

Watershed model runs indicate that the expected shift of land use out of the agricultural and forest categories into urban uses results in no net change in NPS nitrogen and a decrease in NPS phosphorus. Assuming no change in current nutrient control programs, projected year 2000 loads for phosphorus will meet the loading goal; however, the nitrogen goal will not be met. Accelerated implementation of agricultural, urban retrofit, and urban growth management control measures will be needed to meet the nitrogen goal.

2. Inventory of Existing NPS Control Measures

An inventory of existing urban and agricultural BMPs has been compiled and the information is being used in technical analyses. However, information on urban BMPs remains incomplete; counties are working to gather information still needed. In addition, information has been compiled on county and State programs that address NPS pollution.

3. Articulation of Local and State Visions for the River

The Planning Committee also articulated and reviewed local and state visions for the watershed. Local visions were based somewhat on existing county comprehensive plans; a few counties had developed environmental management plans that also offered insight into those counties' visions for the future. Local staff participating in the Project interpreted these plans and added their judgments about their jurisdiction's future directions.

State visions were derived from the Patuxent Policy Plan (mentioned above) and from a state growth management law passed in 1992. They address such issues as where growth and development will occur, where agriculture will be preserved, how storm water runoff will be controlled, where sewer service might be extended, etc.

4. Definition of Management Options

Based on the review of existing NPS control measures, Project participants have defined three basic NPS management options (or scenarios):

- Base case (projected land use changes based on population projections, with no nutrient control efforts beyond currently implemented practices).
- Current BMP implementation (projected land use change with continued agricultural and urban NPS pollution control implementation at current rates).
- Enhanced BMP implementation (projected land use with enhanced implementation of agricultural NPS controls and urban growth management measures, including sensitive area protection, improved storm water management practices, and forest conservation).

Specific land-use changes and the characteristics and extent of BMP implementation have been defined for each option.

Upon completion of the preliminary guidance document (discussed below) and review of the options by each county, county-specific options will be developed and analyzed.

5. Analysis of Management Options

The management options described above are being analyzed using a geographic information system-based NPS accounting system to estimate both acreage changes in different land use categories and the relative change in average annual nutrient loadings due to implementation of the different management options. The accounting system-derived land use acreages and management practice implementation estimates were also applied in the watershed model, along with projected PS flow and loading changes, to determine the hydrologic and nutrient loading changes expected as a result of the base case and management options.

Several analyses are under way: (1) development of more detailed projections of growth, land use change, and the effects of enhanced BMP implementation using the NPS accounting system; (2) watershed model-based projections of the hydrologic and nutrient loading response of the watershed to the enhanced NPS and growth management measures; (3) development of a detailed watershed model to provide better spatial resolution for the hydrologic and nutrient loading assessments needed to evaluate specific county restoration efforts; and (4) linkage of the watershed model results to the estuarine water quality model to estimate the response of the Patuxent estuary to the different management measures.

6. Nonpoint Source Management Guidance Documents

NPS control guidance and recommendations will be developed by the Planning Committee with input from the other two committees. As mentioned above, county staff have previously articulated county visions and potential options. These are being summarized in a preliminary planning guidance document, along with results of the technical analyses described above. The preliminary guidance document will provide the basis for each county to hold an intra-county workshop to transform the preliminary guidance into specific options relevant to the county. Each county's representative to the Planning Committee will then report to the Committee the results of the workshop. These results will be used to develop watershed-wide and county-specific recommendations for further action with the intention of meeting the NPS portion of the Patuxent's nutrient reduction goal.

Information about the relative effects of land-use options, and other NPS control options, on NPS pollution loads will be compiled into the final NPS management guidance document to be produced by the Project participants. This document will also include recommendations concerning which measures state and county governments should adopt.

7. Patuxent Agreement

The options and recommendations in the guidance document will be used as the basis for a Patuxent Agreement. This agreement will be a formal commitment to take specific steps to reduce NPS pollution. One approach may be to assign a nutrient reduction goal to each county, based on the reduction goal assigned to the Patuxent by the Chesapeake Bay tributary strategy. Project plans call for elected executive officials from the seven participating counties and the state to sign this agreement. As with all of the other activities in this Project, the text of the Agreement will be developed by the Project's partners, working through the committees.

8. Implementation Projects

One demonstration implementation project has already been funded; it involves a comprehensive approach to NPS management, including public education and structural retrofits. Approximately 10 other projects are under consideration. Other implementation efforts will follow, and be guided by, the guidance and the Patuxent Agreement.

Lessons Learned

The Project has provided a unique opportunity for state and local staff and resources to work together to develop a strategy for reducing NPS pollution. Given this unique situation, a variety of lessons have been learned to date.

1. Local governments are accustomed to the state's providing direction in

such watershed-planning efforts because of traditional state and local government roles. As a result, local staff required time to feel comfortable working as a team with the state and directing Project activities. Having each of the three committees co-chaired jointly by county and state staff helped speed this process.

2. A watershed strategy for NPS pollution requires a comprehensive and coordinated approach between the federal, state, and local governments. Direct communication and dialogue are necessary between these players in order to develop such a strategy.
3. A project as complex as this one needs clear and widely-accepted goals. The 40 percent Chesapeake Bay nutrient reduction goal and the 1984 Patuxent Policy Plan have been important for this reason.
4. In order to understand existing conditions and to weigh the benefits of various options or management scenarios, dependable modeling is important. Model results and other technical analyses must be closely coordinated with the rest of the Project's activities so that technical and policy analyses may progress into recommendations and implementation measures.
5. Local governments need to understand and accept the models and other technical tools and their results.
6. The committee structure has provided for many types of useful dialogue that did not exist before. Among other things, this dialogue has provided an understanding of and appreciation for the roles, responsibilities, and tasks of other organizations.
7. Different local governments and state agencies have different levels and scopes of expertise; Project activities were refined to accommodate the differences.
8. Both state and local government organizations have tools, approaches, and other resources that are useful for the other partners.
9. Working together, urban-oriented and agriculturally-oriented Project participants have gained a better understanding both of the relative contributions of each sector to NPS loads and of the issues associated with controlling both categories of pollution sources. The need to address both categories comprehensively has also been better recognized through the Project.
10. All sources of NPS pollution must be managed in order to obtain the 40 percent reduction goal. The majority of nonpoint phosphorus and nitrogen loads currently come from agricultural sources in the Patuxent. However, these loads are being replaced by pollution from increasing amounts of urban land. County governments and soil conservation districts will need to cooperate closely to control these pollution loads.
11. The National Pollutant Discharge Elimination System (NPDES) requirements for NPS pollution can serve as an impetus for a local NPS (primarily urban) control strategy, as well as provide good background information.
12. High-level commitment from local governments that control land-use decisions is critical to estuary restoration through watershed management.
13. A strong, institutionalized, adequately-funded focus on the river is needed to coordinate actions taken and report regularly on progress made.

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Building Local Partnerships

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Springfield, Missouri's third largest city, lies in the Ozarks physiographic province, an area of uplifted plateaus covering about 40,000 square miles in southern Missouri, northern Arkansas, and northeastern Oklahoma. It is a region of rolling to rugged hills; clean, clear streams and lakes; oak-hickory-pine forests; and extensive dairy, beef, and poultry farming. Much of the area is characterized by karst topography, a landscape formed by the action of abundant rainfall on soluble limestone and dolomite bedrock. The resultant caves, springs, sinkholes, and losing streams typical of karst terrain certainly add to the beauty and interest of the Ozarks.

Inhabitants of the Ozark region are also interesting and diverse. The traditional "hillbilly" stereotype reflects an early predominance of immigrants from the hill country of Kentucky and Tennessee. These fiercely independent folks settled the Ozark hills passed over by those in search of more productive farmland. The conservative values of the hillbilly are now well mingled with those of folks representing a variety of backgrounds and lifestyles. A mild climate, diversified economic base, modest cost of living, and abundant recreational opportunities have combined to attract a steady influx of settlers to the area. Greene County, which contains the City of Springfield, sustained a 12 percent growth rate in the 1980-1990 census period (185,000 to 208,000 population) compared to a statewide growth rate of 4 percent. The county just to the south of Springfield had the second highest growth rate of any county in the state during this census period—just under 50 percent.

The combination of population growth and karst terrain intensifies the need to carefully manage potentially polluting human activities. A prominent feature of karst is the rapid movement of water into and through the subsurface, with little filtering action in soil or bedrock. Surface water may sink into ground water at a sinkhole or losing stream, cross under a surface drainage divide, and reappear at a spring in a different surface watershed. These attributes present difficulties in terms of watershed management. Water movements do not necessarily respect surface drainage divides. And we can't selectively protect surface or ground water in karst, because they are essentially one and the same.

Spills of hazardous materials, particularly in areas of sinkholes or losing streams, may drain into the ground water system with essentially no attenuation. Catastrophic sinkhole collapses under wastewater lagoons can, and have, released millions of gallons of sewage into the subsurface. Traditionally designed septic systems often allow untreated sewage to leach through thin, rocky Ozark soils into underground water supplies. Even in areas served by public sewage systems, land subsidence associated with karst processes may cause sewers to buckle and leak.

Citizens and elected officials in the Ozarks region have for many years realized the sensitive nature of their water resources. Recognition of this vulnerability by regulatory agencies has resulted in tougher standards on well construction and siting and design of waste treatment facilities in karst areas. Concerns relevant to protecting critical water supplies in a karst terrain directly contributed to the formation of the Watershed Committee in Springfield.

With the rapid population growth in the Springfield area, it was inevitable that large-scale land developments would be proposed within the municipal drinking

water supply watersheds. Several cases presented before local Planning and Zoning Commissions in the early 1980s, especially those involving large numbers of on-site wastewater systems in proximity to the drinking water reservoirs, galvanized local officials to the degradation potential under existing land-use controls. How could we be sure that subsurface movement of sewage in the karst terrain would not pollute the lake? Polarization over development policies in the drinking watersheds nearly drew the local governments and water utility into a court confrontation. A compromise solution was the formation of the Watershed Task Force in 1983, assigned to explore strategies for watershed management that could be embraced by all parties involved. The overriding goal of the Task Force was to "protect the current high quality of the municipal sources of drinking water."

The Task Force attempted to pull together all available information relating to the specific watersheds and wellheads serving the municipal drinking water supply. The city uses diverse sources including both surface and ground water (which, as mentioned earlier, are somewhat artificial distinctions in the Ozarks). Fulbright Spring, the original source of water for the city in the 1880s, still supplies about 20 percent of the annual source water. Fulbright has a recharge area of 15 square miles. Also used are two reservoirs (combined watershed of 40 square miles), the James River (238-square mile watershed above intake), and 11 deep wells.

Recognizing that these watersheds and recharge zones extend beyond the city, and even the county limits, the Task Force emphasized a multijurisdictional approach to management. Further, they predicted that the growth of the city and county would pose increasing threats to water quality, as development that had previously concentrated downstream of drinking water intakes progressed upstream into the watersheds. Finally, the group recommended that an organization be established to provide sustained, comprehensive management for the municipal watersheds. This enabling language preordained the formation of the Watershed Management Coordinating Committee.

At first, some government officials were adamant that this Committee be constructed strictly ad hoc. Their reasoning was that a 2-year life span would be sufficient to gather information and produce recommendations for any needed changes to local regulation or policy. This resistance to the creation of another permanent and potentially burdensome layer of bureaucracy resulted in the adoption of "sunset" provisions on the newly established Watershed Committee. But at the time of sunset review, an outpouring of public support not only extended the Committee's life but also implanted the concept firmly within the community.

The Committee consists of six citizen volunteers, with a paid staff of two—an Executive Director and an Assistant. Funding for the operation of the Committee is provided through a partnership of three local units of government—the City of Springfield, Greene County, and City Utilities of Springfield, which manages the municipal water supply. Each of these three entities chooses one citizen to represent them on the Committee, with the other three members serving at-large. In 1989, the Watershed Management Coordinating Committee changed its name to the less phonetically challenging "Watershed Committee *of the Ozarks*" and incorporated as a nonprofit 501(c)(3) organization. The not-for-profit status allows the Committee to accept tax-deductible contributions from businesses and individuals, and to obtain a reduced bulk mailing rate.

The Committee has functioned since 1984 in a manner generally consistent with the recommendations in the Task Force Report. The overarching goal of the organization is to prevent pollution of the public drinking water sources. In order to accomplish this, the Committee provides review of all rezoning and land development cases within the watershed areas, coordinates watershed management policies and regulations between state and local units of government, promotes and pursues data acquisition projects, and provides water quality educational programs throughout the region.

One of the most profound successes of the Committee has been its ability to bring representatives of local government together to discuss watershed issues on a regular, sustained basis. Before the Watershed Committee, units of government operated somewhat independently with respect to developments in watershed areas. Now, the Committee's input is an integral component of the governmental land development review process. When technical issues arise, the Committee has been able to pull the

necessary resources together from academia, regulatory agencies, and consulting firms to offer realistic and scientifically valid advice. A day-to-day working relationship has been established with the staffs of the County Resource Management Department, the City Planning and Development Department, and City Utilities Water Supply and Management. The Watershed Committee has become an institution accepted and respected by both government and the citizenry.

Over the years, the Committee has administered many studies and projects designed to gather data and provide management options for local governments. One of its first efforts in this regard was the hiring of a consultant in 1984 to provide a thorough survey of water quality threats in the watersheds, and to make recommendations for modifying policies and regulations to address those threats. Most of those recommendations have been put into practice.

Since 1984, four other major data acquisition and information management projects have been administered by the Committee. All have involved cooperative relationships with local, state, federal, and private entities. A 3-year project to develop a geographic information system for Greene County was a joint effort with the U.S. Geological Survey, U.S. Environmental Protection Agency, the Missouri Department of Natural Resources, Southwest Missouri State University, and the Committee's three sponsors. Especially important in this project was a local working partnership with the University, which provided students to field-map sinkholes and digitize information.

The recently begun 319 (section 319, Clean Water Act) Nonpoint Source Project in the Fellows/McDaniel Lake watersheds involves even more cooperators. This project has two major components. An agricultural portion involves the USDA Soil Conservation Service, USDA Agricultural Stabilization and Conservation Service, University of Missouri Extension, Greene County Soil and Water Conservation District, Greene County Resource Management, and the Missouri Department of Conservation; and an on-site wastewater component involves Greene County Resource Management, the Springfield-Greene County Health Department, and the Department of Natural Resources. Springfield City Utilities, Greene County, and the Watershed Committee are jointly managing the project. Nonpoint source projects, by their nature, require a broad-based effort and a flexibility of traditional roles among agencies. All the parties involved in this project have agreed that this is the key to successful implementation of nonpoint strategies. With this understanding, the partnership has functioned smoothly.

One of the more interesting recent partnerships in data acquisition is the Pearson Creek Stormwater Project. The Watershed Committee, City Utilities, and Greene County have determined a need for area-specific storm water quality information on which to base effective management strategies. Storm water runoff and its potential effects on adjacent landowners are issues frequently raised at Planning and Zoning hearings. It was decided to undertake a sampling project, but a major consideration was the ability to obtain sampling manpower. The Committee made contact with a citizen's group in the Pearson basin that had been organized primarily to oppose a specific land development. This group was approached about providing volunteers to help gather storm water data. Seeing that local agencies were sincere in their desire to address these problems, the group became very interested in helping out. Volunteers have now received training and sampling kits and are awaiting their first "event."

Perhaps one of the most visible successes of the Committee has been in the area of community education. The first educational piece produced by the Committee was *Clean Water for Cave Country,* a slide and video program focusing on the vulnerability of ground water in karst terrain. With the assistance of an outreach coordinator, the Committee has recently developed a more integrated program using television public service announcements, newsletters, fact sheets, school programs, and citizen workshops.

The Committee annually sponsors the Watershed Conference, which is designed to provide a regional focus on water quality and water resource issues. This summer, the 7th annual conference will again be supported by many local businesses that have become clean water partners with the Committee. This partnership provides high community visibility for the businesses and helps the Committee to keep registration costs low. This year, the Missouri Department of Natural Resources is cosponsoring a

teacher's water quality workshop to be held in conjunction with the Conference.

Three years ago, the Committee began the watershed Signing Project. Signs along highways at watershed boundaries now notify travelers that they are entering the "Springfield Water Supply Protection Area." These signs were erected in cooperation with the Missouri State Highway Department and are designed to raise awareness and aid in emergency response. An outgrowth of this effort is a cooperative arrangement negotiated through the Greene County Emergency Management Agency whereby fire, police, and sheriff's department personnel are made aware of drinking watershed areas, provided handy maps, and instructed on procedures for alerting water supply personnel in the event of a spill. This spring, an exercise coordinated by the Local Emergency Planning Committee will involve a mock spill within a municipal watershed.

These community-based education programs have built strong public support and increased awareness, as evidenced by surveys and the level of sophistication of public response at forums such as Planning and Zoning meetings. Throughout this awareness-building process, the Committee has relied on partnerships with many state and local organizations whose goals are closely allied, or complementary. For example, the Committee has cosponsored stream cleanups and water quality monitoring workshops with area Stream Teams. This partnership led to one area Stream Team serving as a pilot for the first statewide volunteer water quality monitoring program. In conjunction with the Springfield-Greene County Environmental Advisory Board and Ozark Greenways, a series of activities were organized for Clean Water Month, including an urban stream cleanup assisted by the Governor. The Committee organized the first ever City Stream Festival in Springfield with the promotional help of a local radio station. A partner in this festival was the Household Hazardous Waste Project, which directed a pilot storm drain stenciling project with local 4-H groups. And a local sporting goods store has become a partner in producing Committee "Water Protection at Home" fact sheets for distribution through their large retail outlet. In this case, the theme of clean water accommodated the store's goal of good fishing, as well as the Committee's clean drinking water objectives.

A key to the formation of these successful partnerships is a willingness to be receptive to new opportunities and to explore common ground. The successful operation of these cooperative ventures also implies a basic desire to work together for mutually desirable higher goals. Of course, all such partnerships must be based on respect for alternative points of view, and trust that no hidden agendas are at work. Another important consideration is that each of the partners make clear their desires and expectations at the outset. In spite of the heritage of individualism in the Ozarks, many groups in the Springfield area have shown an inclination, and even an eagerness, to work together on projects of mutual interest.

An indication of the perceived success of the Watershed Committee has been the spawning of similarly organized groups in the region. One important example is the Scenic Riverways Watershed Partnership, a cooperative venture between the Ozark National Scenic Riverways, a unit of the National Park System, and the eight counties surrounding the park. This group, which focuses on watershed protection and education, used the Watershed Committee's by-laws and articles of incorporation as a model for their structure.

Throughout the existence of the Watershed Committee, the most critical partnership has been with the three local sponsoring governmental entities. Their financial and psychological stake in the successful operation of the Committee has insured their consistent appearance at the discussion table, and allowed watershed issues to be addressed up-front, at high level, and cooperatively. Their continued support will keep the Committee functioning as a valuable community resource for watershed management and protection.

Partnerships in Decision Making Within the San Francisco Bay/Delta

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Recently there has been a major shift in how some government agencies are organizing to accomplish their missions or mandates, particularly around watershed management activities. These new organizations are partnerships that combine multiple agencies and interested nongovernmental parties into the decision-making process via an inclusive management structure. This new approach to the business of public policy implementation is anticipated to continue and to evolve as resources become more limited.

These organizations are innovative in their structures, with most developed in an "ad hoc" manner. Their differing structures and operating characteristics exhibit varying degrees of success in supporting decision making and program implementation. Three examples from the San Francisco Bay region are presented and are used to illustrate how these models of partnership work. The three are: the Interagency Ecological Studies Program (IESP), the San Francisco Estuary Project (SFEP), and the Long-Term Management Strategy (LTMS). The IESP, SFEP, and LTMS offer three different organizational structures with dissimilar decision making procedures. In an attempt to distill the best framework to structure new partnerships, this paper examines the decision-making processes of these organizations.

Closure in Decision Making

Using closure as the "target" of the decision-making process, picture a multilayered framework that partitions the process into factors affecting the outcome (Figure 1). Around the central core of closure is a layer of human qualities that are personified in the form of leadership, commitment, and drive of the partnership participants. The next sphere, moving out from the core, is procedural or operational characteristics that define the rules for agreement and procedural conduct among the participants. The outermost layer is the organizational structure that provides the context within which the procedures are implemented by the members of the partnership to arrive at their decisions.

Probably the most complex aspect of this framework is the contribution of human behavior to decision closure. It is clearly the most uncertain aspect. Closure can be

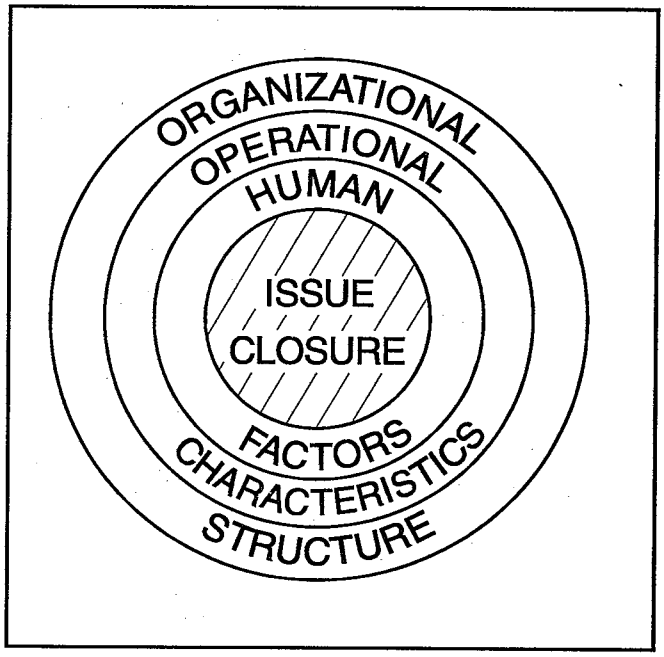

Figure 1. Decision-making "target."

hampered or blocked by one person regardless of how fine the operational characteristics and structure are in a particular partnership. On the other hand, a flawed operating process and organizational structure can be overcome by a strong willingness on the part of the participants to achieve closure. The human factors are the primary "glue" for the nucleus of closure.

Because the human factors are difficult to quantify, this paper will investigate the influence of the second and third layers on decision closure. Assuming that human factors can be removed from the proposed framework by having many of the same people participating in several partnerships within the same region, it is possible to tease out the qualities of the other two layers that contribute to successfully hitting the target. The San Francisco Bay/Delta offers the opportunity to attempt this analysis because there are multiple members, or at least organizations, that overlap among the three regional partnerships.

Regional Partnerships

The IESP was initiated in July 1970 by the U.S. Bureau of Reclamation, U.S. Bureau of Sport Fisheries and Wildlife, California Department of Water Resources, and California Department of Fish and Game. The program was established to investigate impacts of freshwater diversions on fish and wildlife resources in the region. Currently, the IESP includes the original four agencies as well as four more: the U.S. Geological Survey and State Water Resources Control Board (both joining in 1979), the San Francisco District of the Corps of Engineers (joining in 1990), and the U.S. Environmental Protection Agency (joining in 1992). The program has a three-tiered organizational structure that includes the eight agency directors at one level, agency coordinators at the next level, and five technical committees. The program has been overseen by a full-time Study Manager since 1990. The agency directors meet at least once a year to review progress and to resolve major issues regarding differences in agency policies. The agency coordinators meet generally monthly to resolve issues around funding and study organization. The technical committees develop specific study proposals and budgets and exercise technical supervision over individual studies as necessary to accomplish their assigned responsibilities and tasks.

The SFEP is another partnership in the San Francisco Bay/Delta region. The SFEP Management Conference was formally convened in April 1988. The Conference is composed of four hierarchical committees. The executive level participants comprise the Sponsoring Agency Committee and are responsible for overall policy guidance. Sponsoring Agency meetings are held approximately twice a year. The Management Committee is formed by senior level representatives and is the forum created to determine project direction, planning, and budget decisions. Management Committee meetings varied from every 2 to 3 months early in the project to every 2 to 3 weeks near the end. The last two committees, the Public Advisory and the Technical Advisory Committees, provide input up to the Management Committee. Additionally, it is their tasks, respectively, to address public outreach and education and the technical accuracy and feasibility of products and recommendations. Meetings were generally scheduled monthly or as needed. The final product of all these meetings will be a consensus, or near consensus, document presenting the region's plan for the estuary.

The last organization to be examined is the LTMS for dredged material disposed. The LTMS began in January 1990 and is scheduled to be implemented in August 1994. The LTMS partnership was formed to provide a mechanism to build consensus and to support federal cost participation requests from local navigation interests. It involves over 35 different participants including government agencies, environmental organizations, development interests, ports, and fisherman groups. A management structure was discussed and approved by this group in July 1990. Under this management structure, the LTMS is led by an Executive Committee composed of agency heads within the region. This group is regularly advised by the Policy Review Committee (PRC)—composed of all the LTMS participants—on all pertinent issues dealing with local dredging and disposal activities. The Executive Committee and the PRC hold joint meetings approximately quarterly. Work is directed by the Management Committee. The Management Committee oversees the LTMS studies, budget, and schedule. Their meetings are approximately every other month. The day-to-day work is accomplished by three

subordinate Work Groups on ocean, in-bay, and nonaquatic disposal alternatives that have had a regular monthly meeting schedule. A new work group to address political, procedural, and institutional aspects of disposal option implementation was added in 1992. The Implementation Work Group is further subdivided into six task committees dealing with different aspects of issue.

Decision-Making Processes

Each of these three organizations has definable traits that have either enhanced or foiled the success of their decision-making processes. The key factors that they broadly share, which seem to have promoted successful agreements, include commitment, shared visions of desired outcomes, and evolving trust among their participants. These positive commonalities are the glue that binds the partnerships and their component organizations together through difficult moments. Notice that these three factors are first-layer attributes from the earlier described closure framework—human factors.

The common downside of the decision-making processes of the three partnership models is that they are time-consuming and expensive. Public interest groups are particularly vulnerable to the time requirements because they lack funds to support their members' attendance of numerous consensus building meetings. This circumstance impacts the public's ability to participate, either partially or totally, and ultimately weakens the acceptability of the final decision. The following analysis attempts to find other traits and describe their influence on reaching closure in partnership decision making.

Strengths

The other features of the San Francisco models that have allowed difficult issues to be worked include multitiered management and decision-making structures; participation by key stakeholders; and integration of technical, managerial, and policy factors as critical issues are identified.

Multidimensional Participation

The three San Francisco partnerships are hierarchical with compartments for all levels of participation. The visible and active support of senior-level individuals, generally political appointees in agencies, is crucial to sustaining the partnership. Senior leadership focuses on the broad issues the partnership embraces and direction it takes. The IESP, SFEP, and LTMS executive levels provide guidance to their respective programs on the organization's future actions—often what is politically acceptable and achievable. Many political considerations must be folded into the decision-making process and evaluated if implementable decisions are to be rendered. Further, this group has the power to redirect resources if they see that a change in program direction is necessary to be responsive to public or political pressures. In the final analysis, this level has the "power" to make things happen—including pressuring for, or directly making, decisions.

Under the executive level in the three San Francisco examples is a management level. This level is where the program's policies are implemented, including overseeing the distribution of money and staff in order to meet the goals of the program. This group is typically career employees or high level managers. The leadership they offer, in both the IESP and LTMS cases, is limited to how to implement the decisions previously obtained. In the SFEP, the Management Committee can also be the forum to suggest new directions—although this sometimes has led to a conflict with the Sponsoring Agency Committee.

Technical and public advisory compartments also exist within these organizations. In the IESP and LTMS, the technical committees are positioned below the management level—although the LTMS Management Committee has a Technical Review Panel horizontally linked to it for outside technical review. The LTMS also has its public interest comments presented directly to the executive level at their Policy Review Committee meetings. The IESP does not have a public input compartment; however, they do conduct an annual public forum to receive public comment and reaction.

Technical compartment participants are generally specialists framing issues for research and study from an engineering or scientific perspective. This group seems to balk at attempts to involve them in new policy or regulation formulation. The concern most often cited by members is that they would lose their "objective" orientation. The public or interest group compart-

ments, on the other hand, are very sensitive to new policy or regulation development. Their participants are either part of the regulated community or interested laypersons with an advocacy coalition or organization. It is generally their desire to instill their "subjective" desires and values into the negotiation process and effect an outcome that reflects their organization's position. The members of these two auxiliary compartments are frequently first-line supervisors or their staffs. These major units will create service committees or single-issue committees to get a task accomplished or obtain a decision on a specific point. Staff-level specialists who are familiar with the needs, facts, and issues of the particular circumstance being investigated are typically involved.

In short, all levels of skills, knowledge, authority, and experience, from both public and private organizations, can be accommodated within a multi-tiered organization. The involvement of multiple levels of personnel gives the broader partnership strength and vitality because everyone is included and shares in the partnership's accomplishments or failures.

Participation by Key Parties

In 1970, the affected communities in the IESP were forced to the table by Water Rights Decision 1379. Thereafter, other agency interests outside the state mandate including the mandating agency were brought to the table by enlightened self-interest. Currently, the IESP is limited to key agency participants; however, non-agency groups are becoming aggressive in trying to expand the partnership's membership to directly include their point of view and participation. The SFEP and LTMS are both open processes that from the outset solicited participation by all stakeholders. Both of these partnerships acknowledged that if a player is excluded from the table, he or she may become a litigator or project opponent later in the process. Thus, every effort was made in both projects to identify, contact, and include all affected parties. Both programs use newsletters and bulletins as well as public meetings and hearings to encourage participation.

Integration of Information

Although the three organizational structures have specific compartments for participants' perspectives, they also foster overlap to achieve a shared communication network. There are several information sets that participants must deal with and communicate during the decision-making process. Information is power; movement of that information between participants not only empowers participants but also enables integration of concerns and identification of sound alternatives to consider while formulating project decisions. The SFEP and LTMS have formed a series of focused or task committees to work with single issues. These subcommittees were multi-dimensional, drawing on several kinds or dimensions of information. Each of these dimensions was characterized by unique perspectives, and their proponents had specific motivations behind their positions. The outcome of the negotiations within these subcommittees were framed by the participants' access to information and their intentions. By sitting around the table over months to years, the participants developed an understanding of each other's position and the trade-offs in their issue area. Integration of the various constituents' considerations led to stable decisions. These consensus decisions, when elevated to the next higher level, were generally adopted because of their support in the lower, focused work groups.

These three structural strengths are complemented by two key operational characteristics: consensus developed statements of purpose and systems for measuring performance. The SFEP and LTMS have clear purpose statements that define the conceptual framework for their efforts. The IESP lacked such a statement until recently when it was criticized for having an inadequate conceptual basis for its activities. Annual work plans provide a mechanism to measure accomplishments and document successes—all three partnerships use work plans to allocate resources and track tasks.

The development and acceptance of a strong purpose or vision statement by participants provides the foundation for establishment of goals, objectives, and product statements. Under the SFEP, its consensus process utilizes the project's vision statement to measure the significance of its members' concerns to the total project's intentions. At times, these concerns were dismissed in deference to continuing the process given their limited role and impact in attaining the vision. The

LTMS uses ratified (signed by the Executive Committee) statements defining its goals, objectives, products and work plan budget and schedule. This level of detail has allowed the LTMS Management Committee to control and measure progress as well as make mid-stream corrections to project direction to achieve its goals. Further, the ratified documents have allowed the top level participants to be conspicuous about their commitments to the LTMS partnership. Both IESP and SFEP lack these types of ratified documents, and thus sometimes have appeared to be adrift, and participants have questioned their ability to effectively implement decisions.

Formal documents provide participants and outside parties with information about what the partnership is doing and when activities are occurring. The organizational structural and operational characteristics can provide the setting and communication linkages to transfer information between compartments. These attributes are mechanisms that the partnerships can use to build supportable decisions.

Weaknesses

Each of the San Francisco organizations has been functioning for several years or more. During this period, each has received criticism from partners regarding decision making activities—chiefly around operating characteristics. Three operating procedures that influence partnership operation are: whether the organization decides issues by a formal consensus-driven process; process is open to all interested parties; and usage of decision criteria and lines of authority. Weak links in the decision-making process of each San Francisco partnership are suggested in this list. The IESP process suffers from having unequal voices. Two agencies provide most of the budget for the program, thus frequently have the last word with respect to funds allocation—"somewhat" consensus-driven. The roles and responsibilities of the member agencies are not clearly defined in the group's charter; each agency potentially retains unilateral control over its funds and staff. This discretion is a problem when participants believe that their decisions can be subsequently overturned without recourse.

The LTMS is also a "somewhat" consensus-driven process; under its charter, the Executive Committee has the final voice in any decision if consensus has not been achieved at the Policy Review Committee or at a lower level. The LTMS participants are able to meet directly with the Executive Committee. However, sometimes their best arguments do not ensure they get their way. The Executive Committee may find that consensus is not necessary to obtain because either the lack of resources, time, or other constraints override the significance of the proponent's concern. This mixed process frustrates some participants.

Lack of clear decision-making authorities of the component committees and definition of the decision criteria has been the failing of the SFEP. Members of various committees (Management, Technical, and Public) were not informed as to their decision-making authority and abilities with regard to the oversight committee (Sponsoring Agency). Problems arose when decisions achieved by consensus were debated at the executive level and changed. This upset of participants forced, in one case, a "damage control" joint meeting to keep participants from leaving the table. Secondly, decision criteria in a totally consensus-driven circumstance were generally lacking for the first 3 years of the project and continue to be nebulous for some issues at its closing. The absence of criteria led to stalling on decisions for months, and sometimes years, while the issues were discussed again and again or ignored.

Lessons Learned

Reflecting on the descriptions of what has worked for the three partnerships in the San Francisco region, what lessons can be extracted and transferred to future partnership formations? The success of decision-making efforts seems to be influenced by some simple ideas. Participant willingness to reach closure is the primary ingredient for a prosperous partnership. Nevertheless, operating characteristics and organizational structure can aid decision making in these large partnerships when properly implemented.

Operational characteristics that produce closure include:

- Establish clear lines of decision-making authority with defined roles and responsibilities for the organization's components.

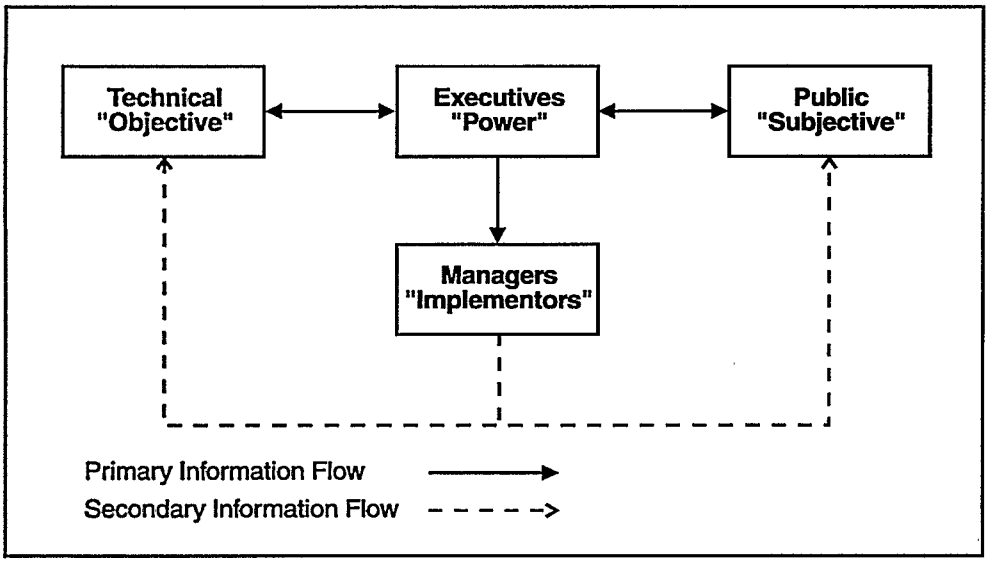

Figure 2. Proposed organizational structure.

An organizational structure is proposed that has the property of being simple while enhancing communication and information exchange. A four-box framework, as shown in Figure 2, places the executive members in a position to directly receive input from the technical and public sectors of the organization.

This improves the likelihood that the partnership is seen as open and responsive to various points of view and concerns. The executive members have the "power" to act on "objective" and "subjective" sources of information as presented in joint meetings. Further, this reduces potential isolation of participants that may otherwise leave the table because of their disagreement with the partnership's decisions. The managers or "implementors" of the partnership's decisions are positioned a tier below the other organizational units. They are responsible for acting on the first tier's decisions and organizing any "issue" committees or other service groups for the broader organization.

- Prepare, adopt, and ratify formal documents that specify the partnership's vision, goals, objectives, and products.
- Agree to a system of performance measures that enable assessment of accountability and timeliness on a regular basis.
- Provide direct support for public interest representation at the table to improve participation and the possibility of an acceptable process outcome.

The Conceptual Foundations of Multiobjective River Basin Planning and Their Contemporary Relevance

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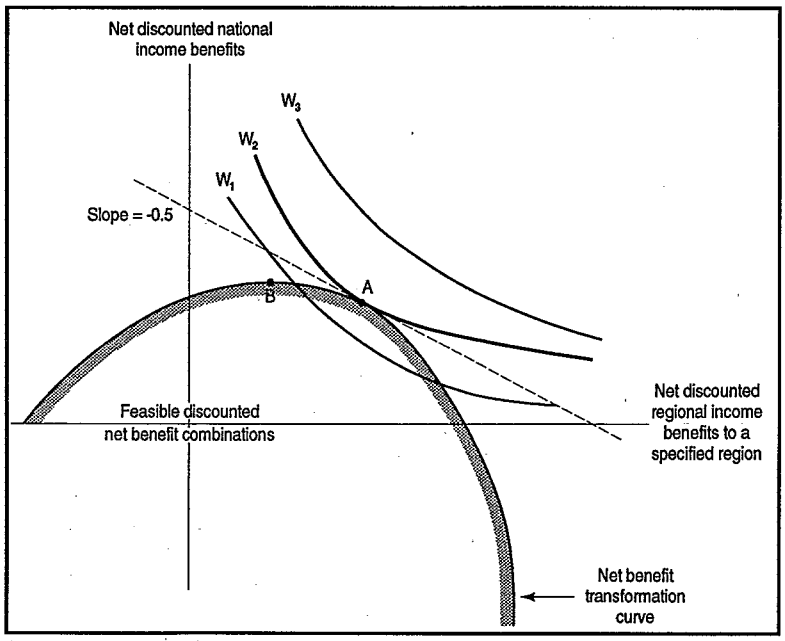
The conceptual foundations of multiobjective (including environmental objectives) river basin planning have developed over a period of more than 30 years, embracing a range of remarkable theoretical developments in economics, political science, engineering, and systems analysis. These foundations have been embodied to a greater or lesser extent in a series of federal water planning guidelines and have been the basis of many applications. This paper provides a succinct statement of the conceptual foundations, describes their reflection in planning guidelines, notes examples of applications, and outlines the relevance of multiobjective planning to river basin (watershed) planning today.

Multiobjective Planning: Conceptual Foundations

Multiobjective analysis is a generalization of traditional benefit-cost analysis. The perceived need for this more general analysis in water resources planning 30 years ago arose from the observation that, while the objectives of water planning in the United States have historically been diverse, the traditional formal analytic criterion—benefit-cost analysis—restricted analysis to only one of many applicable objectives (Major, 1977). Detailed presentations of multiobjective theory, and perspectives on it, can be found in Maass et al. (1962); Maass (1966, 1970); Marglin (1967); United Nations Industrial Development Organization (1972), and Major (1977). References to applications are given below.

Multiobjective theory is shown graphically in Figure 1. (This section follows Major and Schwarz, 1990, pp. 33-35.) This figure shows a multiobjective problem with two objectives: the traditional objective of increasing national income and the objective of increasing income to a particular region. (The rules for counting national and regional income differ; see the references given in the previous paragraph.) Benefits counted toward each objective are



Source: Adapted from Major and Lenton, 1979, p. 31.

Figure 1. Multiobjective theory.

netted and discounted; that is, gross costs are subtracted from gross benefits in each time period of the analysis and the resulting net benefits are reduced to present value. The effects of various management and development options on the objectives are estimated and displayed in the net benefit space formed by the coordinates. These effects can be negative or positive for each objective. The group of attainable net benefit combinations is called the feasible set, and the boundary of this set is called the net benefit transformation curve.

The points of interest to decision makers are the points on the boundary of the feasible set where it slopes from northwest to southeast. From any point on this part of the net benefit transformation curve no move can be made that is unambiguously good; a gain in net benefits toward one objective implies a loss of net benefits toward the other objective. Here preferences must come into play. These are represented by social welfare curves (W1, W2, W3 in Figure 1). Each social welfare curve is a locus of points in net benefit space of equal social utility; a curve farther from the origin represents a higher level of social utility than a curve closer in. The formal purpose of multiobjective planning is to locate that point on the net benefit transformation curve that is tangent to the highest attainable social welfare curve. In Figure 1, point A shows the combination of net benefits toward the two objectives that is attained by implementing the optimal project or program.

The negative of the slope of the tangent line at A gives the weight that society places on an additional dollar of net regional income benefit to the specified region in terms of an additional dollar of net income to the nation. A slope of -0.5 means that the value placed by society on an additional dollar of regional income is 0.5. With this weight on regional benefits, society would be willing to give up at the margin $1 of national income to obtain $2 of regional income. (If we take the weight on national income to be one by convention, (1)$1 = (0.5)$2.0.)

The traditional point of best design is shown by B, the highest attainable level of net discounted national income benefits. Although the results shown in the figure depend on the shapes of the net benefit transformation curve and the social welfare curves, it can be seen that in general A and B will not coincide. This is the reason for using multiobjective rather than traditional benefit-cost analysis in water planning. Multiobjective theory captures the fundamental elements of all social decision making: there is an assessment of both possibilities and preferences, and an integration of the two. Details about the assumptions and qualifications of this analysis are in the references given above. It can be noted here that in practice planners do not have or need all of the information in Figure 1; in applications, the planner strives to develop the information that is necessary to the problem at hand. For example, preferences can be approached by discussion of alternative feasible points, rather than by direct attempts at estimating preference curves. The representation in Figure 1 can be generalized to many dimensions. Beyond three dimensions, the presentation must be in numerical terms. Among the most important objectives in multiobjective planning are environmental objectives (for an example in practice, see Major and Schwarz, 1990, chapter 4). While, to be sure, some environmental considerations can be approximated through national income concepts, environmental objectives partake strongly of the "merit want" concept, in which society's preferences for objectives other than the national income objective are explicitly considered.

Applications and Guidelines

Multiobjectives have been applied in many studies beginning in the 1960s. Among the earliest large-scale applications were the Massachusetts Institute of Technology-Argentina study (Major and Lenton, 1979) and the North Atlantic Regional Study (Major and Schwarz, 1990), both completed in the early 1970s. Applications in substantial numbers have continued to the present. One recent collection of articles on multiobjectives in water resources planning includes 18 papers (Hipel, 1992). In the area of water resources regulations, multiobjective theory formed the basis for the 1973 Principles and Standards of the U.S. Water Resources Council (1973). The preliminary proposals (U.S. Water Resources Council, 1969, 1970 a, b, c, d, 1971) leading up to these regulations are also of interest. An insightful assessment of the multiobjective aspects of the Principles and Standards and later criteria is given in Stakhiv (1986).

Relevance to River Basin (Watershed) Planning Today

Multiobjective planning remains of central importance to river basin and watershed planning today (using the term watershed to mean a constituent part of a river basin). Its strengths remain those that were built into the original conceptual structure: the explicit integration of all relevant social objectives into the planning process; explicit optimizing; the inclusion of the traditional approaches of benefit-cost analysis, pricing, and standard-setting as methods, rather than as goals in themselves; the integration of preferences from the beginning of the planning process; and the integration in water resources planning of the range of applicable social, engineering, and natural sciences. The importance of stressing these strengths is greater than ever. To a significant extent today multiobjective planning as an overall conceptual structure has been replaced by standard-setting. What is simply a method has become nearly the whole of planning for some agencies and purposes, whereas the whole of planning should be captured in the powerful conceptual structure of multiobjective planning.

Especially as new initiatives for watersheds are contemplated, the choice of conceptual basis is an essential one. Watersheds present decision problems that are a complex mixture of physical, engineering, environmental, economic, and social considerations; simple and poorly grounded methods will not suffice. The U.S. Environmental Protection Agency (EPA) is not often thought of as a multiobjective agency, but in fact its work is inextricably bound up with objectives other than environmental ones. A recent emissions trading case is an example where regional considerations are crucial (*New York Times*, March 14, 1993, p. 35); instances where economic objectives matter are commonplace.

The use of multiobjective planning will have significant implications both for EPA's ability to fulfill its watershed planning mission effectively and for staffing. In terms of professionalism (although not of course, in terms of detailed methods or the precise mix of objectives used by the staff), EPA's staff will have to be transformed into the equal of the staffs of the U.S. Forest Service, U.S. Army Corps of Engineers, or the U.S. Geological Survey in the heydays of those agencies. (A substantial improvement in management and staffing is apparently required almost regardless of methods: see the report on the new Director's views in the *Washington Post,* March 11, 1993, p. A18.) One useful way to incorporate multiobjective methods into EPA's procedures would be to undertake several watershed planning and assessment case studies using the conceptual basis and methods of multiobjective planning that are so richly available, with suitable adjustments for EPA's mission. This would be an important start in keeping EPA from continuing to be, conceptually, an agency that is located firmly in the 1930s in terms of its single purpose planning with inflexible planning methods.

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Geographic Approaches to Environmental Management: Bioregionalism Applied

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"The earth does not give itself to us in a global sameness, it gives itself to us in arctic and tropical regions, in seashore and in desert, in prairie lands and woodlands, in mountains and valleys. Out of each unique shaping of life takes place a community, an integral community of all the geological as well as the biological and the human components." —T. Berry, *The Dream of the Earth*

Bioregionalism has been described variously as a "moral philosophy," an action-oriented cultural geography, and an outgrowth of the Green movement (Parsons, 1985; Berry, 1988). E. O. Wilson dates its origins to John Muir (Wilson, 1992). Its present-day apologists include distinguished poets, biologists, theologians, and geographers. Yet it remains difficult to pin down exactly. Bioregionalism is a "mode of consciousness that is groping toward a more precise articulation of its own ideas, its institutional forms, and its most effective programs of action" (Berry, 1988). "The movement has not coalesced around any single philosophy of land management" (Wilson, 1992). Nevertheless, some basic themes of bioregionalism are apparent and have important implications for environmental managers pursuing watershed and other geographic approaches.

First, bioregionalism seeks a reordering of political, economic, and other human institutions around a region or place. It ultimately seeks to redefine community to include all the physical as well as the organic constituents of a place (Berry, 1988). Its goal is the full appreciation and awareness of the biotic community taken in its broadest sense to include human activities as among the interdependent biological and physical processes of the region.

Second, the reordering is to be guided by a new ethic. Not so new, in theory at least, this ethic is essentially an elaboration of Aldo Leopold's land ethic, according to which humans are to become functioning members of the biotic community rather than conquering invaders. Or, as Thomas Berry has put it, "the change is from an exploitative anthropocentrism to a participative biocentrism" (Berry, 1988). In bioregionalism, this ethic has a distinctly local and practical flavor. "Stewardship means, for most of us, find your place on the planet, dig in, and take responsibility from there—the tiresome but tangible work of school boards, county supervisors, local foresters—local politics" (Snyder, 1974).

Third, bioregionalism places a strong emphasis on regional culture and regional autonomy in decision making. Because the function of culture, in the bioregionalists' view, is to mediate between humans and the ecosystem within which they live, culture is necessarily regional. Similarly, because political decision making is dedicated to striking the right balance within the regional biotic community, political decentralization and regional self-determination are essential.

The scale of governmental decision making must be appropriate to the scale of the community served by those decisions.

How We Got to Where We Are

The idea of looking at natural resource issues from a regional perspective is not new. In the early part of this century there was an effort to conduct comprehensive water resource planning on a watershed basis. Historically, however, river basin planning focused only on specific features of the watershed (such as water resource development) rather than on the watershed as a whole. For example, the Water Resources Planning Act of 1965, which provided for a national system of river basin commissions, was undercut by its failure to incorporate environmental concerns. (National Research Council, 1992).[1]

The federal environmental statutes that emerged in the 1970s were typically focused on pollution control and largely ignored broader ecological concerns. Although these statutes have resulted in large reductions in pollution in the last two decades, ecological concerns—including habitat destruction and loss of biodiversity—have intensified during this same period. At the landscape level, the effects of these statutes have often appeared fragmented, piecemeal, or simply inadequate to deal in any comprehensive way with the real problems. The authors of *Water Quality 2000* state:

"[A]fter 20 years of experience with narrowly targeted authorities, technology-forcing regulations, and patchwork programs, we believe the nation is ready to embrace a more holistic approach." (Water Environment Federation, 1992).

In an effort to foster holistic programs, a watershed protection approach has evolved in the U.S. Environmental Protection Agency (EPA). This approach encompasses a broad array of related initiatives including EPA's Great Waterbodies Programs (the Great Lakes, Chesapeake Bay, and the Gulf of Mexico) and the National Estuary Programs, as well as a number of smaller watershed planning and implementation efforts. Efforts of other federal agencies such as the Soil Conservation Service, Fish and Wildlife Service, and Forest Service are also being reoriented around regional watershed models or other ecosystem-level models.

[1]Section 208 of the Federal Water Pollution Control Act Amendments of 1972 represented an effort to plan and manage water quality issues on a watershed scale. However, section 208 provided no money for implementation. The area-wide planning provisions fell short for a number of institutional reasons. (Fox, 1992; National Research Council, 1992).

EPA's Watershed Approach

EPA's watershed approach provides a useful illustration of these geographically-based efforts. In its execution, the watershed approach is diverse; however, there are a number of common elements. First, the watershed approach is holistic and integrated. It addresses not only water quality and quantity but also enhancement and preservation of fisheries and wildlife and the health of land-based ecological communities. It also addresses economic issues because these are part of the dynamic of the biotic community. Among other things, the economic well-being of the human community is a necessary predicate to effective environmental programs and sustainable use of natural resources. The watershed approach seeks to coordinate efforts across geographic boundaries and governmental jurisdictions, as well as across the public and private sectors.

Second, the watershed approach is participatory. It brings together all affected stakeholders—people and organizations with an interest in the watershed and with some ability, individually or collectively, to take action to restore and protect it. Through stakeholder councils, comprehensive plans are developed from diverse perspectives and are implemented through decentralized mechanisms (Lee, 1989).

Third, the tools used in watershed approaches are eclectic and are tailored to the particular problems of each watershed. They include nonregulatory, educational, and outreach efforts as well as more traditional regulatory, public works, and land acquisition programs.

What Does Bioregionalism Have to Offer?

What do the bioregionalists have to offer environmental managers in the design and implementation of watershed or other geographic approaches? Bioregional thinking confirms the basic premises of the

watershed and other geographic approaches. It also illuminates new potential for these approaches. By the same token, real-world experience with geographic approaches is beginning to define the institutional forms through which bioregionalism might be realized.

Bioregionalism confirms, if any confirmation is necessary, the holistic, integrated focus of the watershed and other geographic approaches as well as their decentralized and participatory aspects. But it also adds something that is often missing from formulations of these approaches by environmental managers: the strong environmental ethic that is critical if these approaches are to be successful. While environmental managers often discuss the need for education and outreach, the aim of the bioregionalists is much more fundamental.

The premise of bioregionalism is a widespread understanding and acceptance of not only the complexity and interrelatedness of natural systems but also their multiple values to the human community. This awareness allows the citizens of a watershed or other natural system to see themselves in relationship to their environment and, thereby, bring a new perspective to political and economic decisions affecting their region.

The proliferation of watershed councils and other local and regional environmental efforts suggests the growing strength of an environmental ethic rooted in place. This feeling for the land, the bioregional impulse, is fundamental to the success of all geographic approaches. To foster and inform this impulse, education is key. Aldo Leopold pointed out:

"[I]f the individual has a warm personal understanding of the land, he will perceive of his own accord that it is something more than a breadbasket. He will see land as a community of which he is only a member, albeit now the dominant one. He will see the beauty, as well as the utility, of the whole, and know the two cannot be separated. We love (and make intelligent use of) what we have learned to understand." (Leopold, 1947).

The Senegalese conservationist Bala Dioum was more to the point: "In the end, we will conserve only what we love, we will love only what we understand, and we will understand only what we are taught." (Wilson, 1992).

With an informed appreciation and understanding of ecological relationships, communities can provide integrated responses to resource issues. This model of localized decision making offers a way of overcoming, or at least working through, some of the traditional antagonisms that have plagued environmental policy at a national level: conservation vs. preservation; jobs vs. the environment; utilitarian vs. inherent value of natural resources. By focusing holistically on a specific ecosystem, the communal judgment can be brought to bear in a manner that transcends these divisions. As discussed below, however, this model has its limits and complementary decisional processes at the national and international level will remain necessary.

Qualifications and Complexities

Bioregionalism is visionary. Implementors have to worry about details, about qualifications, about complexities. And there are some important limitations and qualifications to the bioregional vision. First, bioregionalism largely begs the question of scale; second, it does not sufficiently recognize the extra-local origin of many ecological and cultural problems. (Parsons, 1985).

The Problem of Scale

The problem of scale is fundamental. There are no obvious bioregions. A bioregion has been defined as "a geographical province of marked ecological and often cultural unity, its subdivisions, at least ideally, often delimited by watersheds of major streams." (Parsons, 1985). Watersheds are typically seen as "providing the operating basis for organizing and managing the relations between humans and their local environment." (Parsons, 1985). The recent *Water Quality 2000* report stated that watersheds may define the appropriate spatial boundaries for total environmental and economic planning. (Water Environment Federation, 1992).

There are other criteria to delineate bioregions: among them, biotic shift, physiography, and climate. But even if watersheds are accepted as the best way of defining bioregions, the problem of scale remains. *Water Quality 2000* suggests that watershed-based approaches be keyed to U.S. Geological Survey (USGS) hydrologic units, the largest of which encompass the

drainage areas of major river systems; there are 21 such regions in the United States. The report goes on to acknowledge, however, that "[i]n some watersheds, planning and management activities may be more effective in obtaining water quality goals if they are organized by ecological regions (sub-watersheds). This is because the natural difference in climate, geology, soil, land form, and vegetation may not conform strictly to hydrologic regions." (Water Environment Federation, 1992).

In other cases, bioregions may be recognized at a much larger scale. For example, EPA's Gulf of Mexico program is dedicated to addressing comprehensively environmental issues within the entire Gulf ecosystem, including problems that may be created through the various drainages into the Gulf. That system contains five of the major USGS hydrologic regions, as well as the Gulf. Does an effort of this scale fit the bioregional model? Are the Gulf and its drainages (including those from Mexico and Cuba) a bioregion? Or are programs at this level to be viewed as structures to mediate and support smaller, more focused bioregional efforts?

One way to deal with the question of scale is to look at watersheds or other natural systems as "problemsheds," and to determine at what scale the problems in those systems seem most responsive to coherent solutions. In addressing "problemsheds," it is important not to look at problems individually. Since the bioregional approach seeks to view the region as a functioning system, determining the appropriate scale of a bioregion requires consideration of "the major ecological interactions in a watershed, rather than managing for a single species or for a resource commodity such as the game fish." (National Research Council, 1992). The National Research Council suggests that scale be determined by the species requiring the largest home range for survival (e.g., a bearshed).

Another important factor in considering the scale and configuration of bioregions is the ability of a particular bioregion to coalesce human interest in it. This identification is essential; without it, the participative energy necessary to shape a functioning community around a natural system will not exist. We are just beginning to understand the scale or scales at which this identification takes place, and what the necessary prerequisites for it may be.

Extra-Regional Issues

Bioregionalists have emphasized the self-sufficiency and self-determination of bioregions (Berry, 1988; Calenbach, 1975). They have been criticized for not sufficiently recognizing that, at whatever scale and in whatever configuration the bioregion is defined, there will remain extra-local sources of both problems and solutions (Parson, 1985). It is more consistent with our understanding both of the natural world and human institutions to consider bioregions as nonexclusive. Bioregions may be nested: several smaller bioregions (or subregions) may be contained within a larger bioregion. The activities at these different levels will be appropriate to the types of problems to be addressed, and the nature of the constituencies involved, as well as the natural linkages among the systems involved. Some problems (e.g., global warming) must be addressed at the global level. Others must be addressed locally. Potential interactions among regions must also be considered; for example, potential problems such as global climate change may mean that landscape connectivity gecomes critical for species preservation and persistence (Turner, 1989).

The notion that bioregions are not exclusive or self-contained assumes that we will be called on to think and act as citizens of more than one bioregion. This runs the risk that our energies, as citizens of the biosphere, will be dissipated. But the world is complex both in its natural systems and its human institutions. Oversimplifications that do not accurately recognize the full range of problems and solutions can only lead to disappointment. Further, recognizing that bioregions are not exclusive, and may be nested, makes the problems of scale less acute. It gives more flexibility to organize and carry out projects at several levels and to learn, by experiment, about what functions, activities, and problems are appropriately addressed at what levels.

Finally, with regard to the decisional autonomy of bioregions, the history of environmental regulation in this country suggests an important limitation. In the 1970s, strong federal legislation was enacted because economic considerations were seen as overwhelming environmental concerns at the local level. Nationally uniform pollution control measures were judged necessary to set a floor and to limit the ability of eco-

nomic interests to use their leverage to negotiate environmental terms with local or regional interests. The assumption of bioregionalism (and of the implementing management models) is that with full understanding of the natural systems of which they are a part, human beings will act to sustain (to keep in being) those systems. To the extent this may not occur, a national and ultimately perhaps an international set of management functions should be maintained. This is particularly true for natural systems that have special interregional, national, or international value.

Integrating the Bioregional Approach

Bioregionalists would supplant existing forms of government—currently based on arbitrary (nonecological) boundaries—or at least occasion a radical reordering of these institutions. This is implicit in Kirkpatrick Sale's definition of a bioregion as "a place defined by its life forms, its topography and its biota, rather than by human dictates; a region governed by nature, not legislature" (Sale, 1985). This is expecting too much. Donald Alexander points out that while people identify with their geographical region and its natural elements, they also identify with their municipality and their "urban catchment area," which brings rural dwellers into a common bond with their urban counterparts. Municipal and urban catchment area identifications are arguably even stronger today than in the past because of "the minimal role that primary production plays in the life of the area relative to industry and commerce, thus causing people's relationship to the land to be highly mediated." (Alexander, 1990).

Bioregionalists urge that this relationship become direct, and that competing identifications be subsumed within the more compelling connection to the land. The environmental ethic pushes us in this direction. But it remains unrealistic to expect that other institutions to which the public has strong allegiances will be replaced or subsumed any time soon by institutions organized primarily around ecological concepts. Environmental programs at the regional level can gain strength through existing institutions. They can leverage the resources, authorities, and constituencies of those institutions to enhance environmental understanding and to devise and implement coherent environmental strategies. Religious, civic, political, and governmental institutions all can contribute.

The need to integrate bioregional institutions into existing structures will remain paramount, including integration across governmental lines. This integration requires several conditions in order to succeed. It requires leadership to articulate and constantly hold out the vision of human existence within the context of natural systems, with the energy to jump gaps and take actions necessary to move toward that vision. It requires planning processes that can assemble comprehensive views from fragmented perspectives. Finally, it requires the ability to implement through decentralized mechanisms. (Lee, 1989).

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Managing a Desert Ecosystem for Multiple Objectives

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Watershed planning and management is but the latest in a long series of efforts to make rational collective decisions about the relationship of human activity to the hydrologic and associated terrestrial environment. There have been many advances, as well as no small number of mistakes and dead ends, in this history of integrated water resources planning. Watershed planners should build upon those advances and avoid repeating those mistakes. Yet our understanding of the job to be done changes with each successive effort, and the natural and social environment in which watershed planning will be accomplished is now understood somewhat differently than it has been understood in years past. This paper begins with the examination of a current watershed management case study and attempts to draw conclusions from it as to how received doctrine on integrated water resources planning might be updated to provide guidance for future watershed planning efforts.

San Pedro Tales

The San Pedro River flows northward out of Mexico through southern Arizona to join the larger Gila River at Winkleman. The river is perennial for about half of its length and intermittent elsewhere. Perennial flows are supplied through a porous and shallow floodplain aquifer, which has a capacity of about 600 million cubic meters. This aquifer is recharged by surface runoff, inflow from the underlying "regional" aquifer, and incidental recharge from irrigation. Its contents vary seasonally. The regional aquifer, composed of valley fill sediments up to 500 meters deep, contains 60 billion cubic meters of water and is fed by mountain front recharge at a rate of about 30 million cubic meters annually. This, together with the approximately 80 million cubic meters of mean annual runoff, sums to the total annual inflow of about 110 million cubic feet. Of this total inflow, human uses, irrigation being the largest, account for 55 million cubic meters; natural evapotranspiration accounts for 45 million cubic meters; and the remaining 10 million cubic meters is outflow into the Gila River (Arizona Department of Water Resources, 1990).

Most of the perennial reach of the San Pedro River is contained in the San Pedro Riparian National Conservation Area (SPRNCA), which is administered by the U.S. Bureau of Land Management (BLM). This area was acquired and dedicated in 1988 in order to safeguard one of the few remaining flowing streams in Arizona (95 percent of the state's once-flowing streams have been dewatered), its associated riparian ecosystem, and the remarkably wide and unusual range of plant and animal species which occur there.

A modest irrigated agriculture has expanded in the San Pedro Basin since World War II. Some surface water diversion occurs, but most irrigation water is supplied by pumping from the shallow floodplain aquifer. Irrigation is the largest source of anthropogenic depletions in the basin, although BLM has purchased and retired many of the irrigation rights above the SPRNCA.

The federal government also operates Fort Huachuca, an army post which is the basin's principal economic base. Sierra Vista, the largest city in the basin, is adjacent to Fort Huachuca and has grown up

to support it. Both Fort Huachuca and Sierra Vista draw water from the regional aquifer. This has produced a deepening and expanding cone of depression. Pumping depths and costs have been increasing in the Sierra Vista area for years.

A University of Arizona study reports that the cone of depression has at last reached the San Pedro River upstream from the National Conservation Area and will now draw water from it (University of Arizona, 1991). That study confirmed what many had feared, that continued growth in Sierra Vista constitutes a long-term threat to the maintenance of the San Pedro River and its associated riparian areas, including the SPRNCA. Although their study was not exhaustive, the University research team was unable to find or design a policy option which would both preserve the riparian ecosystem and supply additional water to support the future growth of Sierra Vista and Fort Huachuca.

Indeed, even the continuation of current levels of water use there may be incompatible with preservation of the existing resources of the SPRNCA. The effects now being felt by the river are the consequences of pumping years ago, because transit times in the regional aquifer are slow, averaging only 7 meters per year (Putnam et al., 1987). Worse news is already on its way.

At the same time, the Arizona Congressional delegation, at the behest of local growth proponents, have been fighting to keep Fort Huachuca open and even to expand it. The current Pentagon base-closing list indicates that they have been successful, although the state politicians and a local lobbying group, Fort Huachuca 50, bemoan the fact that it will not be expanded to absorb functions from bases slated to be closed (Gamerman, 1993).

Curiously, but typically for a western appropriation doctrine state, Arizona water law does not recognize the hydrologic connection between the regional aquifer and the river and its associated floodplain aquifer. The senior water rights of the SPRNCA, to say nothing of downstream San Pedro water users or of the Gila River Indian Community on the Gila mainstem, are vulnerable to more recent water uses in the Sierra Vista-Fort Huachuca area, even though western water law was designed expressly to avoid such conflicts. Some day that situation will have to change, as the law evolves to reflect modern hydrologic knowledge. Meanwhile, the law offers no means of conflict resolution, and it even encourages denial of the growing problem.

The problems of the San Pedro basin illustrate some of the kinds of difficulties which future watershed planning and management will encounter. The planning process will be pluralistic, involving several levels of government, diverse water management agencies at all levels, fractionated and inconsistent laws and authorities, conflicting interests at the local level, national interests in environmental protection which compete with local interests in economic growth, weak or nonexistent federal programs to resolve conflicts through subsidized distributive political solutions, and recalcitrant conflicts between man and nature for which no good solutions may exist.

Characteristics of the Watershed Planning Environment

Watershed management, like integrated river basin management before it, is holistic. It is based upon a vision of the watershed, including both its non-human and societal components, as a single system of interrelated elements.

Watershed management, unlike integrated river basin management, is focused upon sustainability, not upon development. Although capital-intensive artifacts, such as water control structures, may have a place, the emphasis is rather upon investment in the perpetuation of ecosystems.

Watershed management, unlike the earlier river basin management, conceives "management" broadly, to include the management of human behavior as well as management of the environment. In principle, it is human activity which has become the most influential force affecting the rate and type of change which occurs in many ecosystems. To think of watershed management as excluding the management of human behavior defines the problem too narrowly and inordinately reduces the range of alternative solutions (Lord, 1981b).

Watershed management is properly a concern of all levels of government. Coordinating the actions of so many players, a necessary task in holistic management, is difficult because the objectives and means for attaining those objectives often vary

widely across these levels of government (Lord, 1981a).

The policy tools which are available to the key players in watershed management vary widely; and it is often impossible for one organization, whose authorities are primarily regulatory, to complement the actions of another organization, whose authorities are primarily proprietary (Lord, 1981b).

Watershed management occurs within a framework of law which is fragmented by level of government, by subject matter, and by implementing organization. This creates inconsistencies and, especially, conflicting and inappropriate incentives for both private actors and bureaucrats. Rights and privileges accorded by the law may fail to resolve conflicts between resource users.

The organizations which manage watersheds, and the behavior of the people who use them, are many and their missions and policies are diverse. Each responds to its own clientele groups and defines problems and potential solutions through its own limited perspective.

Watershed management decision making takes place within an environment of inadequate, and often misleading, information. Scarce resources are often dissipated by attempting to address these information gaps without careful identification of what information is most worth obtaining and what the cost of new information may be (Lord, 1974).

Public involvement in watershed management takes many forms. Private landowners and developers are major stakeholders who respond to market forces and who, because they are locally focused, powerfully influence local governments. Environmental groups are well-organized and vocal at both local and national levels, although perhaps less so at the state level. The vast majority of citizens, while sympathetic to environmental protection goals, see the issues involved in managing specific watersheds as remote and relatively inconsequential to them.

Decision making in watershed management too often is characterized by a veto system, in which a well-organized or powerful interest can block any alternative which it perceives to be unfavorable to its well-being.

Insufficient mechanisms exist to facilitate bargaining by compensating potential losers at the expense of potential winners, thus creating positive sum solutions in which no one loses. It is necessary both to discover more efficient Pareto-optimal solutions and to structure property rights so that losers can be compensated by winners.

The balance between private interest and public interest in many watersheds was forged in an earlier era in which private development was conceived to be the primary goal and protection of public values was seen as secondary. Public values must be paramount, but vested interests must receive fair consideration.

Building Upon the Past

The long history of water resource planning in the United States offers many learnings to those who would plan for the management of watersheds for sustainable development. It begins with the pre-World War II experience with the National Resources Planning Board, continues with the federal interagency planning efforts of the 1950s and early '60s, and culminates in the comprehensive river basin planning program of the Water Resources Council, from 1965 until 1981. Some of the successful features of that half century of experience and innovation were a degree of federal interagency coordination, the involvement of state decision makers, the evolution of technically sophisticated project planning and evaluation procedures and, late in the period, the development of public participation and alternative dispute resolution techniques. Among the failures, which are equally valuable from the standpoint of lessons to be learned, were an inability to resolve major interagency disagreements; an inordinately costly, protracted, and unfocused data collection program; a paucity of action recommendations; and a continued overemphasis on construction or engineering alternatives.

The two successes of the federal interagency river basin planning program which should be adopted by watershed planners are the sophisticated planning and evaluation procedures and the public participation and alternative dispute resolution techniques. Countless hours of agency and academic efforts were devoted to the development of the Water Resources Council's *Principles and Standards for Planning Water and Related Land Resource Projects* (U.S. Water Resources Council, 1973). Although few students would agree

totally with all aspects of these procedures as they stood when the Reagan administration substituted a non-mandatory set of Principles and Guidelines for them in 1981, they represent the most complete and technically correct such procedures devised anywhere. There is no need for watershed planners to reinvent the wheel in this respect.

The P&S, as they are called, were designed with the planning and evaluation of capital-intensive construction projects in mind. Their application to planning and evaluation of operating programs is not so straightforward, and further elaboration in this respect seems called for.

The four accounts framework of the P&S is an excellent accounting system for displaying the nationally relevant impacts of development projects. It is too general for displaying local impacts or for providing the group/specific impact data which can support a bargaining process for identifying acceptable alternatives. But these enhancements are easy to make in principle, however difficult may be some of the data disaggregation steps needed to implement them.

Public participation techniques, such as the Corps of Engineers' "Fishbowl Planning" evolved in the 1970s, but fell into disuse as project planning waned in the Reagan years. Such devices make planning an open process in which interest groups can become advocates rather than opponents, because their views are sought and heeded. However, they function best when a single agency is responsible for planning. Ways must be developed to adapt public participation to the multi-government, multi-agency environment which will characterize future watershed management.

Alternative dispute resolution (ADR) techniques go hand in hand with increased public participation, for conflict surfaces earlier and becomes more evident in an open planning process. ADR is just that, an alternative to the formal and institutionalized decision making processes which no longer do their job well. Institutional innovation is needed to get these established institutions back on track; but, meanwhile, ADR will still be needed, and many ADR techniques will find their way into established institutions as a part of this innovation.

The failure of the federal interagency river basin planning program to resolve interagency conflicts is a key lesson for watershed planners. The diversity of federal agencies, their missions, and their interest group clienteles is replicated in the institutional complexity of the watershed management environment. The only solution to this dilemma is greater public participation and a real devolution of decision making power from the Congress, state legislatures, and local general purpose governments to stakeholder groups at the watershed level. Public participation must change from public information to public decision making, and agencies must change from decision makers to information providers and facilitators.

Solutions

Experience has shown that the creation of watershed-based planning and decision making bodies is essential. Such entities need not be all-powerful, but they must have a sufficiently broad mandate to consider all aspects of holistic watershed management.

Participation in these watershed planning and management organizations must be open to all substantial stakeholder groups. While responsive to local interests, the broad national interest in environmental protection and sustainability must be adequately represented as well.

Information production and dissemination must be comprehensive, although far from exhaustive, technically competent, economically efficient, and unbiased. It must reveal imaginative alternatives and potentially consensual bargaining options. The four account framework of the *Principles and Standards*, if further disaggregated, provides an excellent model.

The rules under which these organizations operate must not permit minorities to thwart achievement of the common good, nor should they permit majorities to ride roughshod over the legitimate concerns of minorities. Simple voting, by either unanimity or majority rules, is unlikely to meet this condition.

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Community-Based Natural Resource Planning by Hydrologic Units

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Background of the Natural Resource Planning Initiative in Virginia

In Virginia, 491 hydrologic units were defined and incorporated into the Virginia Geographic Information System. County-level planning maps were produced. A ranking procedure was utilized which considered nonpoint source pollution (NPS) pollution potential as well as water quality problems. As a result of the rankings, each watershed was ranked high, medium, or low priority. These rankings are being used to target Virginia's NPS pollution programs. All USDA Soil Conservation Service (SCS) progress is being coded into the CAMPS data bases using the Hydrologic Units (HUs) for identification and tracking purposes. Some of the state and federal agencies in Virginia have adopted the HU system for management and interagency cooperation purposes.

Community-Based Natural Resource Planning by Hydrologic Units

Natural resource planning can be defined as a process that encourages people within a defined geographical area to come together to identify and discuss mutual problems and needs and, with the help of technical advisors, develop a plan of action that ultimately leads to measured benefits to individuals, groups of people, or to society within or adjacent to that area. (Kitchen-Maran, 1992).

The overall concept of natural resource planning centers on people participating in identification of problems or needs and taking an active role in the solution of these problems. Soil and Water Conservation Districts (SWCDs) serve as the primary facilitator in involving local, state, or federal agencies that are in a position to assist with planning.

The purpose of natural resource planning is to motivate people to identify and fully understand their problems so that beneficial solutions can be discussed and defined. Hopefully, this process will subsequently lead to implementation and the improvement of life.

The Step-by-Step Planning Process

The natural resource planning process involves a step-by-step procedure that requires the interaction of several interest groups to develop a viable plan. The outlined approach is summarized as follows:

Step 1—Resource Concerns Identified at the Local Level

Before initiating development of a natural resource plan the priority resource concerns need to be established and agreed upon by everyone at the local level. This step is critical in setting the direction of the effort. This could result from a formal request, but generally will correspond to a review of county concerns and selecting an area with an identified problem(s) and/or resource needs where local people have demonstrated a willingness to apply conservation systems.

Step 2—Background Resource Data Gathered

Once the HU has been selected several maps and basic data should be prepared for

the unit. It is recommended that the following maps be prepared: photobase map, detailed soil map, land use map, and topographic map. These should be mosaic maps using the available map scale, generally 4 inch = 1 mile, for the photobase, soils, and land use maps. The topographic map should be 7.5 minute, if available.

Additionally, one to three of the major resource concerns in the HU should be inventoried. These basic data provide "lead in" materials as key leaders in the unit are approached to discuss local problems, explain the natural resource planning process and ask for their leadership assistance. Keep this background data as basic as possible. Do not generate much new data.

Step 3—Key People Form Planning Committee

The district conservationist, along with the Soil and Water Conservation District (SWCD), DSWC, Cooperative Extension Service, etc., should identify five to eight key people in the HU with whom they and others will develop the natural resource plan. Once these key leaders have been selected the district conservationist, along with an SWCD board member, are ready to meet individually with each to:

- Discuss the selected hydrologic unit.
- Briefly explain the need for local input and his or her selection to assist with plan development.
- Ask them to identify problems and concerns.
- Ask them to serve on the planning committee

At least one district board member should participate as a facilitator to the local group if possible. His or her primary purpose would be to show SWCD support and to make certain that other agency people are invited to assist in the planning process.

Step 4—Planning Committee Meeting Held

The committee meets to discuss and fully identify the important concerns or problems of the hydrologic unit. The committee should determine the level of inventory and identify other agencies to invite to assist with the plan development. At this meeting the objectives of the planning committee should be identified and a chairman should be selected. A plan of work should be developed by the planning committee.

Step 5—The Public Is Informed

A letter to all landusers in the hydrologic unit should be drafted by the committee. It should cover the following items:

- Purpose of the HU planning effort.
- List of members of the planning committee.
- List of problems identified.
- A request for their help to broaden list.
- An invitation to call or discuss the problems with the committee members informally.

The SWCD, Agricultural Stabilization and Conservation Service, and SCS should help develop a list of all landusers in the watershed and make a mailing list for the committee. Additionally, the newspaper or other news media should be used to make others aware of the HU targeting and planning activities.

A public meeting may be held as an alternative method of informing the public and obtaining essential feedback.

Step 6—Technical Advisory Committee Appointed by the SWCD

The planning committee identifies where planning assistance might be available to help them find ways to solve the problems they have identified. The SWCD chairman will send letters, cosigned by the planning committee chairman, to all individuals or groups identified as technical advisors for plan development.

Step 7—Technical Advisory Committee Conducts Inventories and Evaluations

Inventories and evaluations will be completed by the necessary technical advisory committee members. These inventories will identify the existing conditions or problems in the watershed that local people want to solve. The evaluations will identify what needs to be done to correct the problems. Basic data will be presented and discussed with the planning committee. All agencies involved with the data collection should participate with the data presentation. After inventories and evaluations are discussed, objectives of the planning committee should be clarified.

Step 8—Alternative Solutions Provided to Planning Committee

Alternatives will be developed by the technical advisory committee to solve the problems and meet the objectives the planning committee has identified. Alternatives will include sufficient cost-return data to guide the decisionmaking process.

Step 9—Public Meeting Held to Review and Discuss Alternatives

The planning committee will hold a public meeting to discuss the data collected. The alternative solutions and their planned benefits will be identified and discussed. All agency people involved with the plan development will be asked to participate as needed. Input from the public will be considered before final alternatives are selected.

Step 10—Planning Committee Selects Preferred Alternative(s)

After the public meeting the planning committee will select the preferred alternative(s). This strategy will fully outline the actions that will be taken to address the local concerns and objectives. The actions will show who (what agency), what (action), and when (month, year) the action will be initiated and completed as fully as possible.

Step 11—Plan Adopted by the SWCD

The plan chosen by the planning committee should be formally adopted by the SWCD before implementation begins. This is not required, but suggested, to ensure that local elected officials are familiar with and support the plan.

Step 12—Resource Plan Implemented

The strategy and actions as outlined by the planning committee are set into motion as indicated in the plan. Copies of the plan should be provided to all persons or groups who will participate with implementation.

Step 13—Plan Reviewed, Evaluated and Updated as Needed

The progress toward implementation will be reviewed at least once a year with the planning committee, technical advisory committee, and/or the public. This will permit the committees to evaluate the impacts and make necessary revisions or updates in a timely manner.

Advantages of Community-Based Natural Resource Planning

Local people, making decisions that ultimately affect and improve the communities in which they live and work, quickly realize the advantages of this approach. A few advantages are listed below:

1. *Local involvement and decisionmaking.* When local people have input in determining resource concerns and needs, and developing objectives and goals, they will support the actions and programs that address those needs. They develop "ownership" and "buy-in" to the project.
2. *Local participation broadens support.* The *most* important part of this process is local participation in planning and *implementation.* Local participation provides the leadership and broadens the support for the planning efforts. Peer interaction of neighbors and citizens in a small geographic area increases support and leads to actions by individuals to do their part. This accelerates project implementation.
3. *Framework for measuring off-site benefits.* People in an HU can relate to the on-site and off-site effects of their resource use and management. They see the effects in their community. By knowing the off-site benefits of various conservation systems, landusers can make better decisions about which systems to adopt to provide a balance of benefits.
4. *Local people select programs to meet goals.* All natural resource programs can be used as applicable to solve identified concerns. Local decisionmakers select and implement programs to meet their long-range objectives.
5. *Framework for targeting specific audiences.* Solutions to various resource problems such as soil erosion, water quality, flooding, etc.,

are closely related. The HU provides a mechanism to address these major issues and to obtain tangible benefits from actions.

6. *Efficient method for delivery of services.* Conservation planning and application activities can be scheduled and delivered in an efficient manner using the HU approach. Common concerns and objectives can be addressed through group planning. Newsletters and other mailings can be concentrated on HUs.
7. *Permits close interaction of agencies and organizations.* Coordinated assistance can be provided in a unit to solve the objectives and meet the local needs. The SWCD requests the needed assistance from the various agencies and outlines agency roles and program expectations.
8. *Framework for evaluating land treatment strategies and impacts.* HU codes in CAMPS will provide progress reporting by each unit. Other databases and models can provide additional analysis and progress reporting support to the HU. The models also can predict what types of on- and off-site resources will be enhanced by various activities. These data will provide progress updates to the steering committees.

Vision for the Future

The following is a hypothetical example of a successful community-based natural resource planning situation that symbolizes a vision for the future.

The SWCD is approached by a group of local farmers and community leaders with a specific natural resource problem. The SWCD works with the local field office staff to verify and document the problem. Local leaders are organized into a planning committee and hold their first meeting. A plan of work is developed which identifies the resources to be inventoried and the technical agencies who are needed to assist with the inventories. The general public is informed of the targeted watershed, and people actively voice their problems and concerns at a public meeting. The technical advisory committee conducts the necessary inventories and evaluations of the identified natural resource problems. Alternative solutions are developed that meet the planning committee's objectives. A second public meeting is held to review and discuss the alternatives. After input from the public, the planning committee selects the preferred alternative(s). The plan is adopted by the SWCD and implemented by the local citizenry.

As best management practices are applied, the progress is entered into a tracking system. The data derived from the tracking system are put into a geographic information system and nonpoint source computer models. The models are run and the output provided to the SWCD and the planning committee. The output is comprehensive and adequate to properly evaluate the impacts of the implementation. The model is also run to determine the projected future resource conditions, modeling both with and without project implementation. Monitoring stations are established in strategic locations throughout the watershed. The public is informed of the progress and the monitoring and modeling results. Further actions are conducted as necessary to complete the project and improve the natural resources to their designated beneficial uses. After completion of the project, the local community thrives economically, enjoying the fruits of a productive nation in harmony with a quality environment.

Summary

Community-based natural resource planning has evolved in Virginia due to extensive cooperation and coordination between federal, state, regional, and local units of government, the citizenry, and the multiple resource concerns in the Commonwealth. The planning base maps, background inventory data, and HU prioritization are available statewide. With leadership provided by local SWCDs, voluntary involvement by private landowners, improved media relations, enhanced education and information activities, and technical support provided by various agencies and organizations, this approach provides the ultimate vehicle to get things done.

The Southern Virginia River Basin Study is one example of the success SCS has had using the previously described planning process. That study is being used

in seven major drainage basins in Virginia to prioritize individual HUs based on a number of various resource data. Local steering committees were formed in each basin consisting of various county officials, SWCD directors, farmers, and landowners to assist the river basin coordinating committee in conducting the study. The steering committees were very active in each basin. They identified local resource problems and concerns, provided study oversight, and adopted the study results as their implementation plan. The information contained in the study reports is being used by the local steering committees to evaluate and address their high-priority resource treatment needs and to secure funding from all available sources for implementation. (*Southern Virginia River Basin Study, 1991-1997*).

Unprecedented federal, state, and local partnerships must be forged in order to make a significant improvement in the many sources of nonpoint pollution currently having an impact on the Nation's natural resources. The collective technical, financial, information, and managerial resources available from all agencies, local organizations, and the general public must be focused to meet the challenges ahead.

The community-based natural resource planning approach described herein will stand the test of time and become the most efficient and effective method of getting conservation on the ground. This will ultimately lead to improved water quality and overall natural resource conditions in Virginia.

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Watershed Planning and Management

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"Water is one of the strongest elements on earth: It can't be broken; it can assume many shapes; it joins easily with itself. When it reaches a certain mass, moving water presents an irresistible force."

—Karen Casey

In the 1990s, a renewed interest in watershed planning and management has raised the concept to such a level that it is considered a key element in future national water policy formulation. No single organization can take credit for this happening. It seems as if suddenly everyone became aware of the methodology for planning and managing water quality and quantity that the U.S. Geological Survey (USGS) had been using for years. Each organization and person now promoting the watershed concept arrived from a different starting point. The organization Water Quality 2000 was initiated at a Wingspread Conference in 1988 and 1 year later adopted its *vision statement*: "Society living in harmony with healthy natural systems," and *goal*: "To develop and implement an integrated policy for the nation to protect and enhance water quality that supports society living in harmony with healthy natural systems."

Water Quality 2000 is a cooperative effort of more than 80 public, private, and nonprofit organizations. Using the following four-phase cooperative effort, the organization has developed a framework to propose and promote new national policies to protect water resources:

- *Phase I:* Feasibility and Plan Development (Vision and Goal).
- *Phase II:* Problem Identification (Challenges for the Future).
- *Phase III:* Recommendation for Improvement (National Water Agenda).
- *Phase IV*: Implementation (Promote adoption of National Water Agenda).

The single most important recommendation to emerge from Water Quality 2000 Phase III is a call for a national policy for total protection of surface and ground water resources. It should be based on the concepts of:

- Protecting water resources by preventing pollution.
- Empowering all segments of society to contribute to water quality improvements through individual and collective responsibilities.
- Planning and managing water quality and quantity on a watershed basis.

In short, an integrated national water policy that supports society living in harmony with natural systems.

Effective watershed planning and management must include the implementation of pollution prevention and empowerment of society. However, this paper will focus primarily on logistics of watershed planning and management as reported by Water Quality 2000.

Watershed planning efforts to date strongly suggest that individual watersheds are the most logical geographical units to use to identify holistic cause-and-effect water quality relationships, link upstream uses to downstream effects, develop reasonable water cleanup plans, target limited resources, and educate and involve the public.

The primary national water quality effort over the past several decades has

relied on standard technologies or management approaches that could be expected to reduce pollution from point sources regardless of their location. However, many of the remaining water quality problems across the country are attributable to runoff from agricultural, urban, and suburban lands.

In contrast to the problems posed by a manageable number of point sources, whose discharges have been relatively predictable, the problems associated with runoff are far more complex. Runoff problems are often related more to individual actions than to single pollutant sources; there are as many different sources of runoff as there are land uses. Both the quality and quantity of runoff depend on local topography, soils, and rainfall. Under these conditions, solutions based exclusively on a standard national approach seem unlikely to be successful. Controls developed at the national and state levels must be combined with individually developed strategies for unique river basins, watersheds, and collection basins or receiving waters, including most of the Nation's estuaries. The watershed approach may be the only sensible way to address point sources and runoff in an integrated fashion.

Promoting the implementation and funding of protection efforts within watersheds motivates individual action and provides the public reasonable assurance that those asked to pay for cleanup also will be able to enjoy its benefits. Citizens are usually more interested and involved when they can identify with a nearby stream, lake, or watershed area.

Management institutions organized by watershed provide far better opportunity to resolve intergovernmental or interjurisdictional conflicts through collaborative, consensus-based techniques. Local incentive to participate in such processes should be enhanced to the extent that participants can be assured that all are equal in the process and that results will benefit their community.

Watersheds provide the flexibility to address water quality and water quantity problems and their interaction in the different climatic settings found throughout the Nation; water quality-quantity problems in the arid West are far different from those in the Northeast. Thus, watersheds allow for the development of total resource protection plans tailored to the conditions in the area of interest.

Watersheds also may be the appropriate spatial boundaries for total environmental and economic planning. Water is one of the keystones for all levels of biological organization as well as all organized economic activity. Ultimately, all activities in or on the air, land, and water can be measured in terms of their effects on water quality, water quantity, or aquatic resources. It seems sensible, therefore, to evaluate the acceptability of environmental protection and economic development activities on the basis of their effects on aquatic resources within the watershed.

Watershed-based management allows for better accountability in protecting water resources. Water Quality 2000 findings concluded that clean water programs may have been more effective than current data indicates. The inability to measure success is a result of the lack of baseline data and statistics related to progress over time. In addition, monitoring efforts have historically focused on water chemistry instead of other indicators, such as physical habitat, flow, and biology. The watershed provides a logical basis for integrated, coordinated monitoring. Data can then be used as a management tool to manage for environmental results. The data can be used to establish priorities and goals within the watershed, evaluate the success of protection efforts, and focus limited resources on the most effective approaches and actions.

USGS hydrologic units allow for consistently derived waterbody segments within which watershed-based measures can be implemented. There are four levels of hydrologic units; the largest, *regions*, encompasses the drainage of major river systems. The regions are divided into *subregions, accounting units*, and *cataloging units*. This hierarchy provides the flexibility to address water quality problems at appropriate scales.

Surface hydrologic units may be used to address ground water issues for some types of aquifers, but not for others. In particular, shallow, unconfined aquifers usually can be managed within surface water boundaries because they are highly connected to surface waters. Deeper, confined aquifers generally cannot be protected effectively within surface water boundaries because these aquifers transgress such boundaries and are not well connected to surface water. Ground water protection is an integral part of holistic watershed planning. Recognizing that aquifers do not always follow watershed boundaries, watershed institutions should create ways to plan

for protection of ground-water resources that cross watershed boundaries.

Under U.S. Environmental Protection Agency (EPA) and state leadership, amendments to the 1972 Clean Water Act have resulted in several useful models of watershed *planning*. However, little progress has been made in the area of watershed *management*. States are also recognizing the need to manage their natural resources on an increasingly broader scale. Today, 36 states support regional or river basin approaches to natural resources management. Typically these efforts are designed as consensus-based policy making or planning processes; states facilitate the creation and implementation of integrated land use, development, and conservation goals in cooperation with local public and private interests. Yet, most states would probably agree that their administrative and political structures may have to change to better support comprehensive natural resources management.

Such change cannot be successful without a parallel reevaluation of federal water quality, natural resources, and related statutes as well as the programs they engender. The 1972 Clean Water Act called for the development of areawide waste treatment plans (section 208). These regional plans were expected to coordinate all surface and ground water quality initiatives under a management strategy to control or treat industrial and municipal point sources, agricultural and urban runoff, silviculture, construction, mining, saltwater intrusion, runoff from solid waste sites, and accumulated sources of pollution such as deposits in harbors.

Despite a relatively comprehensive design and the expenditure of millions of dollars in federal funds, the section 208 planning process failed to attain its goals. Over time, regulators and engineers were able to achieve significant improvements in some waterbodies by controlling point sources. Planners were unsuccessful in convincing decision makers to address the full range of sources. The failure to address the full range of sources was attributable to program delays caused, in part, by lack of EPA guidance. This lack of guidance had the following results:

- A planning process out of synchronization with the construction of facilities.
- Federal funding priorities that favored installation of point source controls in advance of planning.
- State and local government resistance to using the 208 process for land use control.

Areawide water quality management may have been ahead of its time in 1972. Today, after 20 years of experience with narrowly targeted authorities, technology-forcing regulations, and patchwork programs, we believe the Nation is ready to embrace a more holistic approach. The challenge this time will be to move beyond *planning* and actually *implement* integrated, watershed-based protection of water resources.

Water Quality 2000 Recommendations

Congress should create a new national program of watershed planning and management, including a mandate for implementation of activities as a condition of participating in planning. Congress should impose no particular management form on the states and should build upon existing watershed mechanisms. Planning and management institutions should be required for all 21 of the major riverine watersheds in the United States. Where watersheds fall entirely within state boundaries, intrastate management institutions may be appropriate. Where water resource systems extend beyond state boundaries, Congress should encourage, authorize, and approve the creation of interstate regional mechanisms, including joint federal-interstate compacts, as requested by the states, to plan and manage water resources. New planning and management institutions should be created with care—on the basis of water quality priorities and expressions of local interest and commitment.

These new public jurisdictions must be empowered to undertake the range of functions necessary to achieve coordinated use and conservation of water resources. Intrastate and interstate water resources coordination institutions should be established pursuant to negotiations among participating parties. These institutions should be independent, within the context of the broader hierarchy of watersheds, and attentive to the concerns of all affected levels of government and public and private interests. They should be financed, to the extent possible, by parties to the agreement; empowered to take effective action within the scope of responsibility agreed to; and directed by parties of the agreement.

Watershed planning and management institutions should be nested, reflecting the multiple orders of progressively larger watersheds. Institutions created to manage the smallest watersheds (corresponding to one of the 2,150 USGS cataloguing units) should participate in planning and managing the larger watersheds to which they belong and selecting priority areas within watersheds for action.

A nested hierarchy could be organized at the top with an umbrella planning institution representing each of the 21 major riverine watersheds, the largest of the watershed divisions in the United States.

It could be expected that more planning and less management will occur at the largest watershed level. To the extent that federal-interstate jurisdictions are created, for example, they may be well suited to setting performance goals, coordinating the activities of signatory states and their jurisdictions, handling disputes, and raising revenues for implementation. More localized watersheds are probably better suited to sponsor hands-on resource protection, conservation, and use activities, consistent with local goals and preferences. Local management plans must reflect the unique characteristics of the watershed, including those that affect the hydrologic cycle (precipitation, runoff, ground-water percolation, and evapotranspiration), topography, soils, land use, socioeconomics, and institutions. At the same time, however, plans must take a systems perspective by developing a comprehensive water resources management program that includes water supply, water quality, water conservation, flood protection, land use, and protection of living resources and their habitats.

Watershed management efforts may have to turn to the federal government for activities in which there is a clear advantage to a federal role. Obvious examples include setting national water quality criteria and effluent guidelines as well as drinking water standards. The federal government alone can coordinate the federal agencies to improve collection and dissemination of water resources data and the research and development of effective tools for watershed planning.

Case Study

In recent history, the water conflicts that have long been part of water quantity management west of the Mississippi River have moved to the southeast states. The topography of the State of Georgia forms a ridge line whereby all precipitation flows out of the state to the Atlantic Ocean or to another state. Georgia has been aggressive in its water management planning and has utilized federal, local, and private funds to develop a water resource system that provides for flood control, power generation, water supply, water quality, recreation, and navigation.

The Atlanta Region has benefited from this planning and has been able to grow as a result of the construction of Buford Dam/Lake Lanier in 1957. The Buford Dam/Lake Lanier project is a federal U.S. Army Corps of Engineers (COE) project that releases water into the Chattahoochee River. Original authorization documentation for the project clearly indicates that water supply and water quality for the Atlanta Region was a purpose of the project. In 1972, Congress authorized the Metropolitan Atlanta Water Resource Management Study (MAWRS) to develop a long-range water supply management plan. The study verified that the Lake Lanier/Chattahoochee River was the only reasonable major source of water for the Atlanta Region and studied many alternatives for its management. In 1981, the MAWRS study recommended that a reregulation dam be constructed below Buford Dam, which would be designed to capture weekday hydropower surges from Buford Dam and release them at times in a manner more suited to water supply demand. The reregulation dam was authorized in the Federal Water Resources Act of 1986 with the conditions that environmental and economics issues be evaluated. Strong environmental opposition existed and in 1988 the COE changed its recommendation from construction of a reregulation damn to the reallocation of 20 percent of the water stored in Lake Lanier from hydropower to water supply. The proposed reallocation would meet the water supply needs of Atlanta Region and other Lake Lanier uses until the year 2010.

In October of 1989, the COE produced a draft Post-Authorization-Change Report (PAC) which indicated that the impacts of reallocation on downstream users would be minor and insignificant. However, during the public hearings, public concerns and false perceptions caused the reallocation proposal to become a controversial project,

and caused anti-Atlanta and anti-COE sentiments to surface.

Later in 1989, Congress directed the COE to develop another study. This study will be a year 2040 study of the Alabama-Coosa-Tallapoosa and Apalachicola-Chattahoochee-Flint River Basins. It appears that this study is an attempt to restudy the reallocation of Lake Lanier. The study also proposes to study many other aspects of water resources such as water quality standards and the Georgia Regional Reservoir program. In June of 1990, the State of Alabama filed a lawsuit and was joined by the State of Florida to prevent the COE from entering into any agreements for Atlanta's water supply.

To put the lawsuit aside, the States of Alabama, Georgia, and Florida signed a Memorandum of Understanding and agreed to cooperate in a Comprehensive Study of the Alabama-Coosa-Tallapoosa and Apalachicola-Chattahoochee-Flint River Basins. The original study was to take 4 years and cost $4 million. It is now estimated that the study will take 6 to 8 years and could cost up to $12 million. As shown by this example, watershed planning and management can be time consuming and costly.

Therefore, it is imperative that as we work to develop federal and local legislation to promote watershed planning and management, we provide the way to success. Any new watershed legislation or regulations should be goal oriented and not be encumbered with bureaucracy that will discourage participation in the holistic watershed approach to improving the Nation's water resources.

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Challenges in Watershed Activism—Changing Our River Legacies

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"Everybody has to go down the river sometime. What river, well some river, some kind of river. Huck Finn said that and if he didn't say it he should have said it. If he didn't, I will."
—Edward Abbey, *One Life At A Time, Please*

I've got to say, with that quote as our background, that it's great to be here. Great to see so many people interested in rivers and watershed protection. There is a tremendous amount of wisdom and commitment in this audience (what else could you be but committed or committable—to work in environmental protection and restoration!), and I am hoping that together with the rest of our panelists we will tap into that wisdom here in the next hour.

Speaking of committed people—a few years ago, a person I really admire, Professor Richard Brooks, the founding Director of the Environmental Law Center at Vermont Law School, had to introduce me at a public function. Now Dick and I have known each other for a long time, first while I was a student of his in several classes, later as we did a lot of research and writing together, and by the time of this story, as professional colleagues and friends. Well, sometimes friends know more about individuals than they think about, and Dick knew for a long time that I can be persistent and cantankerous and more than a little bit eclectic in my approaches to environmental challenges but he always thought of me as a *committed* environmental activist. And indeed, when it came time to introduce me, he meant to say that I was a "committed" environmentalist only instead it came out as Peter is a persistent and "committable" environmentalist! After he thought about it for a few seconds, he decided that was a better way to introduce me anyway.

Be that as it may, I am here this afternoon as a committed, or committable river advocate, your choice, to discuss some disturbing trends about rivers and river systems in North America and to discuss the interplay of science and public policy and environmental protection. I hope with this brief talk and our discussion we can explore what is necessary for each and how they can best work together to protect and restore rivers.

First I want to tell you a story and then make some disclaimers.

The Brook

How many of you know your ecological address? Do you know exactly where you live? Do you know what watershed you live in? Well my current ecological or watershed address is quite a bit different from the one I had for the first 18 years of my life; it is in a different state and many hours away. I grew up in what was then a small mill town in the Lakes Region of New Hampshire. Specifically, I grew up along the banks of what I knew as a child as "THE BROOK," Dunham Brook in Tilton, NH. I was lucky enough to live in an area where there were about 2 square miles of undeveloped land surrounding the upper reaches of Dunham Brook, and although my parents only owned a very small piece of the land, I and the other seven kids in the neighborhood thought it was our backyard. When I got a little older, about 7 or 8 years old or

so, I began to realize that the brook crossed School Street below my parents' house and went past a cow field, through some woods, crossed under a power line, skirted the back edge of a gravel mining operation, and ran into a natural cranberry bog and then a pond at the end of Bittern Lane, where my Great Aunt Fran lived. The brook left the pond, through a small dam, and went under the highway, down the hill, and into the Winnipesaukee River.

I got a little older and traveled a little more, by bicycle mostly, and then made an important discovery. The Winnipesaukee River flowed into the next town, met with the Pemigewasset and formed a much larger river—the mighty Merrimack—with which I was already well acquainted because the Merrimack was paralleled by the main highway in New Hampshire which led to my grandparents house in Nashua. I live today, after many escapades on rivers and brooks across the United States, far from the Merrimack watershed, in the middle of a large urban area along the Willamette River in Oregon, but the parallels in the two watersheds are closer than I ever could have imagined as a child.

Your Ecological Address

It is terribly important, for every person here in this room, to know their ecological address. It is fundamental to the work you do as environmental engineers, resource scientists, regulatory administrators, and environmental activists, and it is fundamental to the work I do with citizen activists all over the continent. It is fundamental because it shows an understanding of our place in the ecosystem, and knowledge of our place in the ecosystem clearly indicates an understanding of the interconnectedness of the human and natural environment.

We are going to return to my first ecological address, to "The Brook," later in this discussion because the changes in Dunham Brook over the last 30 years illustrate the problems and opportunities facing North American streams today.

Now the disclaimers: You know from my biography and the introduction what I am—a committable river activist, public policy advocate, environmental lawyer, and land use planner by training; now I'll tell you what I am not. I am not a scientist—though I consider myself somewhat scientifically literate, and I have an undergraduate background in geology along with a few graduate science courses here and there. I am not an expert on salmon or biochemistry, geophysics, ecology, or many of the other important disciplines which may be represented here today. Be that as it may, I want to discuss some of the important scientific trends affecting river watersheds today and discuss them in a way which will illuminate and broaden the interplay of science and public policy, citizen action, and governmental initiatives in environmental protection and restoration.

North American Context

The United States has nearly 5.2 million kilometers (nearly 3.25 million miles) of rivers, comprising more than 100,000 streams (Benke, 1990). In many ways, rivers represent the most visible successes of the past two decades of major environmental protection legislation. Most U.S. rivers are no longer visibly polluted with the sludge and changing colors from the industrial discharges and algal blooms that led the Merrimack and Nashua Rivers in New England to be characterized by the late 1960s as "too thin to plow and too thick to drink." (Sludge in the Nashua river grew to the point that small birds were filmed walking on the crust of sludge in what once was a free-flowing, forested, and wildlife-filled river. Many of the conditions were repeated on the industrial rivers of Providence, RI, and across the United States for decades.)

Gross water quality has improved, fish and other aquatic species have been restored in many formerly "dead" sections of rivers, and the Cuyahoga no longer catches fire. Indeed, after two decades of sewage treatment and over half a billion dollars in federal and state expenditures, the Merrimack River now supplies drinking water to over 300,000 people in its watershed and the river is seeing a resurgence of its once tremendous anadromous fishery with the return of American Shad and a tenuous return of Atlantic Salmon. (USEPA Region I, 1987)

Yet healthy river systems are a finite and vanishing resource. The vast majority have been drained, dammed, ditched, overdeveloped, and/or choked with pollution. Many, if not most, of our rivers are in danger of losing their most basic natural

features, capacities, and ecological balance (Table 1).

Rivers are the ecological infrastructure of the continent, the roads and pipes, if you will, of our natural systems, the veins and arteries of the watershed body. It is truly the river's life transporting function that determines the health and ultimate survival of the patient. Rivers provide natural valley flood storage, wetland and wildlife habitat, and a tremendous diversity of aquatic and land species. Rivers are the scene of tremendous natural vistas, impressive displays of nature's power, and conversely, contemplative opportunities central to our lives as thinking humans— attributes needing far more protection than they currently receive.

In addition to serving as critical habitats in themselves, rivers perform a larger function in the natural realm. They connect the mountains to the sea, link headwaters areas to lowlands, and provide a continent-wide system of pathways for the movement and genetic mixing of plant and animal species. This mixing, to the extent it can occur on rivers that have undergone extensive development, biologically strengthens all of the areas that rivers affect by connecting our most significant natural areas—mountains and coasts, forests and refuges—one to the other.

In many ways rivers have also been, and are, the primary natural economic infrastructure, serving as natural sources for waste disposal, power supply, transportation corridors, drinking water, and recreational use. Unfortunately, the history of human development in North America, and throughout the world, since 1600, has shown an ever-increasing destructive capacity to natural riverine systems. The veins and arteries are denuded of their supportive organs while simultaneously overloaded with sediment and other waste products.

Now, when most people think about the natural environment, flowing freshwater is a nearly forgotten resource system. In the biodiversity or endangered species crises we hear about all the time, much attention is given to rain forests, wetlands, and marine systems. We all know about the California Condor and the spotted owl, but who knows about endangered clams, crawfish, or damselflies? Flowing freshwater systems (isn't that a complicated phrase for rivers?), which nurture and connect all of those other areas, have received far less attention.

Table 1. Streams and rivers status and trends

- 5.2 million km of rivers in continental United States
- Only 2% are healthy enough to be considered high quality and worthy of protection
- Of large rivers (>1000 km long) only Yellowstone not severely altered
- Of medium-sized rivers (>200 km long) only 42 have not been dammed

Source: Benke, 1990.

Rivers and streams are sometimes viewed as lacking the biological richness and charismatic species of other resource systems. One study on the subject by scholars at the University of Michigan states that fish have few advocates and invertebrates even fewer (Miller et al., 1989). Yet rivers are frequently part of complex systems that are valuable in themselves; are the beginning of the natural food chains; and, as moving, dynamic systems, are essential to the survival of other ecosystems. (See generally *Restoration of Aquatic Ecosystems*, Cairns et al., 1992)

The loss of natural rivers and the degradation of river systems in the U.S. has critical implications that go far beyond the river courses we seek to protect. Many of the rivers we seek to protect constitute our most important water supplies, have enormously important recreation and aesthetic value, and provide irreplaceable habitat for plants, fish, and wildlife. We need to gain a greater public understanding of, and give increased policy consideration to, the role that natural rivers and streams play in enhancing the daily life of each and every citizen. In particular we need to communicate river protection in ways that people can relate to. People relate to what they can taste, touch, and feel. Waste products and recycling are popular and easy to understand because we have to deal with them each and every day as part of living. The importance of river molluscs (clams and snails), macroinvertebrates (bugs), and their relationship to a healthy and natural environment is a much more difficult concept for the general public to grasp.

Ecological Shock

In nearly 15 years of professional experience in environmental protection and advocacy, I thought I was so jaded that I

was beyond the stage of being shocked because I had seen so many horrors perpetrated on the environment. But I have to tell you, I was shocked by some studies I learned about 2 years ago.

The major point of these articles is quite horrifying—they show that *one-third* of the freshwater fish species in North America, *two-thirds* of North American crayfish, and *nearly three-fourths* of mussel species are now *rare or imperiled. Habitat change and destruction* and *water pollution* account for up to 90 percent of the problem.

Current trends reveal a crisis in biodiversity and an inability of current environmental protection laws and efforts to protect endangered species on a piecemeal or systematic basis. These trends are particularly true for rivers and their watersheds. The latest addition to my filing system includes an "Ecosystem Collapse" file which contains a number of recent studies and articles illustrating trends regularly reported in the scientific literature and the popular press. Recent studies by the The Nature Conservancy, The American Fisheries Society, and the National Research Council of the National Academy of Sciences (Cairns et al., 1992) show that flowing freshwater systems (read rivers!) are far more damaged than terrestrial systems. The Nature Conservancy Study (Master, 1990) concluded that one-third of all native freshwater fish species in the United States are threatened or endangered and that 20 percent of all aquatic species are threatened.

The American Fisheries Society study (Nehlsen et al., 1991) found an equally disturbing set of facts for anadromous fish, concluding that 214 salmon and steelhead fish stocks in the Northwest are now threatened; 101 of these are near extinction. We also know that eastern anadromous fish species—the Atlantic Salmon and shad—are gone from most of their original spawning grounds due to river development, pollution, and dam building.

All three studies cite the loss of riverine habitat and biological stream function due to dams, water diversions, channelization, deforestation, and streamside activities as the major causes of species decline. The Nature Conservancy study concludes that riverine development and habitat loss play a key role in *93 percent* of the instances of aquatic species decline. Because many ecologists believe that rivers are the true indicators of general ecological health, these precipitous declines take on an even greater significance.

Think about this for a second. *One study,* by the Nature Conservancy, concluded that *fully one-third of all native freshwater fish species in the United States are threatened or endangered. Moreover, 20 percent of all aquatic species are threatened.* This is a ratio that is much higher than terrestrial species and causes biologists to speculate that our rivers are the first to register the impact of our long-standing development activities upon our natural systems. *Indeed, while 10 native U.S. fish species have gone extinct in the past 10 years, no terrestrial species are known to have become extinct in that same period.*

Additions to the "Ecosystem Collapse" file accumulate regularly. Recent pieces include Congressional testimony in April 1992 by Dr. James R. Karr, Director of the Institute for Environmental Studies at the University of Washington; a survey of studies indicating the collapse of many toad and frog populations around the world (Yoffe, 1992); and, hot off the press, an inch-thick study by the Pacific Rivers Council (and a team of top research scientists including Dr. Karr) called *Entering the Watershed - a Report to Congress by the Pacific Rivers Council* (Pacific Rivers Council, 1993).

Dr. Karr's testimony to Congress, accompanied by a grim list of statistics (Table 2) states, "Simply put, the ecology of North American Rivers has been decimated by the actions of human society . . . . But river degradation goes beyond the loss of species. Sport and commercial fisheries of the U.S. have also been decimated by human actions during this century. Commercial fishery harvest in rivers such as the Columbia, Missouri, and Illinois, have declined by over 80 percent during this century." Karr goes on to ask, "How would we respond as a society if our agricultural productivity declined by over 75 percent? Can we continue to ignore declines of that magnitude in river resources?"

Emily Yoffe's stark cover story, "The Silence of the Frogs," for the *New York Times Magazine* provides yet another illustration of the ecological shock affecting North American freshwater systems and amphibian populations collapsing throughout the world (Table 3). Studies collected by the Declining Amphibian Populations Task Force headquartered in Corvallis, OR, show almost one-third of

North America's 86 species of frogs and toads appear endangered and or extinct. David Wake, director of the Museum of Vertebrate Zoology at the University of California at Berkeley, says, "My theory is that it's general environmental degradation. That's the worst thing. . . . Frogs are in essence a messenger. This is about biodiversity and disintegration, the destruction of our total environment." (Yoffe, 1992, p 64.)

The most comprehensive collection to date of the ecological crises facing North American rivers is contained in *Entering the Watershed* by the Pacific Rivers Council. Documented impacts include the estimated disappearance of 70-90 percent of natural riparian vegetation due to human activities and the fact that 70 percent of U.S. rivers and streams have been impaired by flow alteration.

Taken together, or even individually, these studies provide initial evidence and warning that the entirety of many of our natural systems may be overloaded and *in some form of ecological shock.*

Today's Challenge

It is my belief that the fundamental measure of environmental protection in the U.S. lies in the way we treat our river systems. Current patterns cannot be sustained without causing extensive extinction of species and major and fundamental changes to our riverine environment.

Everything humans do to the air, the soil, to ground water, and to surface waters will eventually affect our river systems. Great progress has been shown in gross water quality improvement in industrial disposal rivers, including the site of my current ecological address on the Willamette. The clean-up programs initiated over the past 25 years work as they are designed to—when they are given a chance. But mere improvement in sewage treatment and reduction in waste disposal inputs alone will not save our river systems. Across this country the creeping suburbia, exemplified by the tremendous coastal and river bank development boom of 1980s, threatens to undo the progress represented by water quality improvements since the passage of the sewage treatment mandates in the federal Clean Water Act. The explosion in destructive shoreline development, ironically made attractive by the improvements in water quality, threatens to permanently cripple the natural habitat and other resources that make our rivers so important to a sustainable natural environment.

Table 2. Aquatic biota status and trends

- 20% native fishes of Western United States extinct or endangered (Miller, 1989)
- 32% of Colorado river native fish extinct, endangered, or threatened (Carlson and Muth, 1989)
- Since 1910, Columbia River salmonid runs declined 75-85% (Ebel et al., 1989)
- Since 1945, Missouri River commercial harvest down over 80% (Hesse et al., 1989)
- Since 1850, 45% to 70% of fish species in rivers of Midwest declined or disappeared (Karr et al., 1985)
- Since 1933, 20% of molluscs in Tennessee River system lost (Williams et al., 1989)
- 46% of remaining molluscs are endangered or seriously threatened throughout their range (Jenkinson, 1981)
- 38 states reported fish consumption closures, restrictions, or advisories in 1985 (Moyer, 1986)

Source: Karr, 1992.

Table 3. Collapsing amphibian populations

North America

Western toad (*Bufo boreas*): Plentiful in Colorado in 1972. Population began collapsing in 1973. Extirpated in Colorado 1979.

Wyoming toad: dozens of sites in 1946; one site left 1993.

Yosemite toad: endangered.

Mountain yellow-legged frogs: one site left 1989.

Red-legged frog: in serious decline.

Cascades frog: two found 1991; none 1992.

Costa Rica Monteverde Cloud Forest Reserve

Golden toad: 1964-1987 thousands found
1988 one
1990 none since

Glass frog: known as "jewels in the night" these small lime green frogs with a see-through underside and large quizzical eyes were abundant until the late 1980s; now they can hardly be found.

Riverfront land has become so attractive (because the river no longer is full of highly visible pollutants), that areas which never should be developed—including buffer strips and wetlands, are facing more development and destruction pressure than ever before. This kind of rampant, ecologically unsound development is also no friend of the economy—as witnessed by what the real estate speculation of the last few years did to the health of the economy in New England and is doing to California today.

As an individual who regularly hikes, kayaks, rafts, and canoes the estuaries and rivers of North America, I have seen this trend with my own trained and environmentally aware eyes in all its unnecessary tragedy over the past decade. These trends are fundamentally incompatible to the survival of the natural environment and the survival of a healthy and economically productive human environment.

Traditional Approaches to River Protection

What do we do well, and what have we done traditionally in river protection activities? We focus on water quality; we focus, particularly in the West, on water supply.

In a lot of areas we focus on dams and mostly on preventing dams, in the few stretches of rivers that haven't been dammed. Occasionally and historically we focussed on the land along the river banks and tried to protect it. Look at greenways. Along with those foci are traditional technical fixes to the degradation and devastation of our water quality and water supply: sewage treatment plants, discharge permits, wetlands mitigation and replication. All of those traditional "fixes" merely condition continuing problems. These approaches have some mitigation benefit, but I have a problem with the whole concept of mitigation because one gives up 90 percent of the battle by accepting that whole idea. Mitigation only slows the harmful effects addressed by discharge permits, dredge and fill permits, development, and habitual destruction; because population numbers and development pressures continually increase—one never stays even—one always loses with mitigation programs.

Traditional approaches also spend a lot of energy with state and federal agencies which live and breathe these technical fixes. In fact, most of the agencies were set up simply to implement these discharge permits and enforce the degradation of our water supply—if you want to take a cynical view of environmental law protection.

When a lot of time is spent on these agencies and these technical fixes, critical problems which are noticeable even to the "uninformed person" on the street are ignored. All of the professionals in the agencies and the river groups, myself included, have been caught in this pattern many times. We spend so much time looking at the battle of the day, and the mitigation project, and trying to condition a development or put a technical fix on the end of the sewer pipe, that we miss the larger issues illustrated in the studies discussed earlier in this presentation.

New Approaches

What we don't do, or what we don't do very well at least, is address river issues on a watershed-wide basis. We don't design our programs to address the fundamental interconnections between water quality, water supply, wetlands, air quality, wildlife habitat.

That's tough to do and it's fine to stand up here and talk about what we don't do, but how do we do it? I think we need to step back a little bit and we need to put real faith and effort into a concept that has been around for a while and gets talked about a lot and never gets done—to address these issues with a bioregional focus, to plan our efforts to restore and protect the environment on an ecosystem basis, using watersheds as the basic unit.

What does this mean on a practical basis? It means redirecting agency work, in addition to redirecting the work of private nonprofit river protection and advocacy groups—to step back and take a look at the watershed, take a look at the global issues in the watershed, and then figure out how we are going to apply our daily battles to those issues in a proactive way.

Watershed approaches involve a tough step by step process allocating precious resources and limited staff. It means stepping back a little, trying to figure out what the critical issues, what the global issues for the watershed are, and it also means making tough choices to get away

from spending a lot of time in the conservation commission hearings, and in the state permitting statutes, and spending more time and effort on political change which allows for comprehensive approaches attacking broader issues.

Many nonprofit river groups have begun that process over the last 10 years. It is not easy, and it *is* easy to get caught up in the day-to-day grind. One of the key ways to get to that process involves political change for redirecting agency efforts. We are seeing the beginning of this kind of change with the new administration in Washington, and some of the changes in Congress and the states. When agency efforts are redirected to watershed approaches, they inevitably have to face what I call global issues within the watershed and what are in fact global issues of resource depletion and degradation. When you talk about resource depletion and resource degradation in the United States, you have to step back and look at our per capita consumption of resources. We consume well over 10 times the average amount of resources of the rest of the world. When you put that in the context of even the relatively low population in the United States compared to the rest of the world, you are still talking about major resource problems that we have to deal with now, in one way or another.

I have presented a few provocative statements here and I hope they spur thoughtful reflection. It is key to remember, however, this idea of watershed approaches is not new. This whole idea of planning water basins and using the resources and protecting and restoring the resources on a watershed wide basis, an ecosystem basis, was first proposed in the United States by Major John Wesley Powell long before anybody knew what an ecosystem was. You can read about the history of his proposals for the West and how far they got, and why they eventually didn't get anywhere in the new edition of a classic environmental work *The Silent Crisis in the Next Generation* by Stewart Udall, former Secretary of the Interior (Udall, 1988). I highly recommend the book for an interesting history of river protection, among other topics, in the United States.

Opportunity

There is a great deal of activity in river conservation. The *1992 River Conservation Directory* (published by the National Park Service and American Rivers) lists 1,640 private and public agencies at the national, state, and local levels. What's missing is a movement. There is no broad national consciousness that rivers are vital and threatened, nor is there much cooperation or support among all these organizations.

River Network sees a major opportunity for river conservation in this country, with the following elements:

First, the situation has reached a crisis stage that can no longer be ignored. With dried-up streams in the West, fouled streams in the East and endangered fish species everywhere, the public is ready for change.

Second, there is a large and growing number of activists throughout the country who are ready to work for river protection. They tend to be isolated and frustrated, but they are highly committed.

Third, several issues are coming to the fore that will focus public and legislative attention on river protection. The next few years will see the reauthorization of the Clean Water Act and the Endangered Species Act, the listing of many fish species as threatened and endangered, and the 50-year federal relicensing of some 200 private dams.

Backlash

Countering this opportunity, we see several negatives:

- First, there is a growing backlash against environmental protection, particularly in rural areas.
- Second, the tools at hand for river protection are woefully inadequate. The Wild and Scenic Rivers Act is not doing the job for the vast majority of rivers.
- Third, national environmental organizations are able to devote very little energy to forging a movement and empowering the grass-roots. By necessity, most of their energy goes to working with Congress, administrative agencies, the courts, and the media.
- Fourth, public funding for river restoration (including purchase of river lands) is dwindling.

1990s—Decade of River Conservation

Given the river-related issues that the country faces, the 1990s could be the decade

of river conservation. We could strengthen the Clean Water Act, demand strong recovery plans for endangered fish species, negotiate far-reaching mitigation for dams that are being relicensed, and forge and pass comprehensive new tools for river protection.

To take advantage of these opportunities, however, it will be necessary to mobilize a grass-roots movement that can counteract the influence of the "backlash" that is becoming more and more organized. The framework for a grass-roots movement is there in the 1,000 or more river guardian groups across the country. It doesn't seem, however, that any other national organizations are prepared to focus on this grass-roots constituency. (One exception: the area of stream monitoring.) Quite understandably, the national organizations want to focus their energies on the more direct roles of lobbying, litigation, intervention with agencies, and gaining media attention for river issues. (It is interesting to note, in this context, the complete absence of any inclusion of the tremendous accomplishments, success, and potential for change represented by the thousands of locally and regionally based nonprofit citizens river protection organizations in either the working groups, studies, or recommendations of the *Water Quality 2000* reports assembled by a working group of agency officials, national environmental groups, and industry representatives. (Water Environment Federation, 1992))

National Rivers Campaign

The challenge, then, is to work at the regional, state, and grass-roots levels to foster a cohesive movement of river and watershed conservation. This means recruiting and empowering leaders. It means building organizations capable of carrying out campaigns. It means linking up all these leaders and organizations so that they can work together for the common goal: to stem the tide of river deterioration and forge new tools for river conservation.

To this end the Pacific Rivers Council, American Rivers, the American Whitewater Affiliation, River Network, and a number of other organizations have banded together to take advantage of the opportunities discussed above and expand on them in a new National Rivers Campaign over the next 8 years. This will be the first time a comprehensive national campaign to protect both public and private lands rivers has been attempted. Campaign goals include a coordinated Strategic National Watershed Restoration Initiative, major changes to the Clean Water Act, reorganization of the U.S. Environmental Protection Agency, uniform and consistent standards for all federal land agencies, ecosystem and watershed-level planning by all federal agencies, a comprehensive ecosystem-based watershed restoration program, a moratorium on new dam construction, periodic "State of the Nation's Rivers" reports, and stable long-term funding and sufficient financial and tax incentives for riverine restoration. (*Entering The Watershed*, Pacific Rivers Council, 1993).

Return to Dunham Brook

Where do I think these efforts will go to meet the challenges of the next 10 years? How do we most effectively use the data gathered by the Pacific Rivers Council, The Nature Conservancy, and the American Fisheries Society? Site specific threats literally occur by the thousands. I said at the beginning that I wanted to return to the story of Dunham Brook. Three years ago I visited the brook for the first time in about 10 years, and what I found then is indicative of the challenges and opportunities facing North American rivers over the next 8 years.

When I was a child, hiking up and down, and fishing and swimming in The Brook, most of the brook was fairly well-insulated from direct human impact. There were only about 3 houses within 300 yards of the brook—now there are over 40 in the upper reaches. In the summer now, little or no water is left in this stretch. It is silted and dried up. There are no fish left here, no turtles, no salamanders for little kids to play with and discover as they poke sticks into the water and overturn rocks. The gravel pit has expanded and diverted the course of what was left of the stream in the last major visible stretch, and there are no bitterns left in the cranberry bog. The pond drained in a trickle to the Winnipesaukee. A sad story for a lost resource.

There may yet be a happy ending, however. In a brief visit to my hometown last week, just before the blizzard of '93, I heard some fish stories from a 71-year-old family friend and avid fisherman. Russell told me some low-key natural restoration has taken place in the lower stretch of the

brook below the new houses. Beavers have returned above the gravel pit, damned the brook, and created new fishing holes. Russell claims he fished to his daily catch limit in the beaver impoundment twice last summer. These claims were hard to evaluate or even reach under last week's 2 feet of snow, but I'll return in June to walk the length of the brook and report back to you in the future.

What this anecdote reveals, however, is the tremendous resilience of the resource if it is helped along, and it also reveals the possibility of restoration of its entire length with changes in the way the resource is used. Restoration of the many Dunham Brooks across this great continent is where I hope the myriad efforts of citizen activists, volunteer monitors, restoration ecologists, visionary politicians, business interests, and many others will go between now and the next century.

Dunham Brook, and the thousands like it all over America, represents a challenge for the next 10 years, a challenge that the determination of the people in this room can meet and succeed with. The challenge then, is to take the example faced by Dunham Brook, or the Blackstone Valley, or the Pawtuxet, or Moshassuck; the Winnipesaukee, the Woonasquatucket, or the Stilliguamish; the Salmon, Snake, Rogue, Columbia, or Willamette rivers, *your ecological address*, and ratchet up river protection to a new level of political awareness, protection, and effective restoration. To change the way we approach science and reductionist study and to address the trends that are so very clear with holistic approaches and innovative solutions.

In closing, I'm going to leave you with another quote from Edward Abbey - one we need to take to heart and practice in our daily lives. It goes like this:

> One final paragraph of advice: Do not burn yourselves out. Be as I am—a reluctant enthusiast . . . a part-time crusader, a half-hearted fanatic. Save the other half of yourselves and your lives for pleasure and adventure. It is not enough to fight for the land; it is even more important to enjoy it. While you can. While it's still here. So get out there and hunt and fish and mess around with your friends, ramble out yonder and explore the forests, encounter the grizz, climb the mountains, bag the peaks, run the rivers, breathe deep of that yet sweet and lucid air, sit quietly for a while and contemplate the precious stillness, that lovely, mysterious and awesome space. Enjoy yourselves, keep your brain in your head and your head firmly attached to the body, the body active and alive, and I promise you this much: I promise you this one sweet victory over our enemies, over those desk-bound people with their hearts in a safe deposit box and their eyes hypnotized by desk calculators. I promise you this: you will outlive the bastards.
>
> Thank you very much.

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A New Philosophy for the Environmental Regulatory Process

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Prince George's County, MD, is a major suburb of Washington, DC, extending east and south of the District of Columbia. It is about 500 square miles in area and has a 1992 population of approximately 740,000 people. The area of the county immediately next to Washington is intensely urbanized; the county also contains sprawling suburban communities and picturesque rural and agricultural areas.

The "regulatory process" that is the subject of this paper is the local government environmental protection process. At the local level the most significant environmental regulatory activity concerns land development. Land development and the management of associated infrastructure contribute significantly to water quality problems particularly in urban areas. Nevertheless, the thesis advanced here is relevant to all areas of regulation, including the federal and state environmental regulatory processes.

The parts of the regulatory process that are examined are the fundamental framework and philosophy within which regulation is done. This paper proposes that the relationships between the public and private sectors and among governmental agencies at all levels of government be redefined.

There always has been, and probably always will be, *tension* between levels of government—between the state and local governments, as well as between the state and federal levels. It seems to be the nature of the republic that there be rivalry and competition between the various levels. These rivalries have been so bitter and destructive that today there is considerable distrust among governmental agencies and between levels of government. In addition, there is a special kind of bad will between public sector regulators and private sector land developers. We in local government all have stories of environmental atrocities carried out by one development project or another. Local business representatives can also tell their own stories of abominations perpetrated in the name of environmental protection or of being trapped in some local environmental *Catch 22* crafted by the local regulatory bureaucracy. This atmosphere disrupts the economic viability of private sector projects, making it difficult for them to succeed and be profitable. Ultimately this is destructive of the community's economic well-being.

It is proposed here that, in the best American tradition, we make these rivalries a positive force in the Nation and a starting point for a new approach to the environmental regulatory process.

By way of responding to the destructive nature of the existing system, a new philosophy and approach to the process of managing environmental regulation are being used successfully in Prince George's County, MD. This new philosophy and process recognize and respect those natural tensions in intergovernmental relations and attempt to reverse the destructive tendencies that characterize relations between the public and private sectors.

The new philosophy is based on the following five principles:

1. Establish and share a *vision* of environmental quality in a context of community well-being and economic prosperity.
2. Build *trust* among public agencies at all levels and between the public and private sectors.

3. Respect the *connectedness* of everything in natural and socioeconomic systems.
4. Have *sensitivity* to the needs of the regulated community, particularly with respect to market and economic forces.
5. Use good *judgment*, assess the risks, evaluate outcomes, make appropriate changes.

Principle Number 1: Establish and Share a Vision of Environmental Quality in a Context of Community Well-Being and Economic Prosperity

The concept of vision, sometimes expressed as "visualizing," is used in many contexts today. It is a component of Total Quality Management and other team building and management frameworks. A vision, as used here, is a perception in the human mind (imagination) that embodies the characteristics that the organization, or in this case the community, would choose to have.

Having a vision makes a difference! The County Executive of Prince George's County, Parris N. Glendening, established a vision for the county early in his first administration. He thought it was important to reverse the perception within the region and the county itself that Prince George's County was a second-class community; that the county was the low end of the market for development; that Prince George's County is the place in the Washington Metropolitan region to build cinder block warehouses and low-rent garden apartments. Through his public statements and implementation of policy, he made it clear that the county welcomed high-quality development but would not tolerate low-end projects that would drag down the county's economy. Further, he insisted that having high-quality development was not good enough and that, in fact, development could not be of high quality unless it protects and enhances environmental quality. He reinforced this view by consistently reiterating that a healthy and productive natural environment *is consistent* with good, profitable development. The vision he promoted is capsuled in the following statement: *Quality development that embodies environmental quality, to provide improved quality of life for Prince George's County.*

The environmental vision should incorporate cultural, public safety, and economic considerations as well as those of the environment. Glendening was clear that his vision included better schools and improved police and fire protection as well as forest habitat protection and restoration of water quality. Another vision, albeit a more restricted one, many people are familiar with is the Clean Water Act goal of "fishable and swimmable" waters for the United States.

The components of a vision must be integrated: *Yes* to forests, habitat, clean water, clean air, and *yes* to other aspirations for our community, such as high-paying jobs, successful businesses, homes in good communities, public safety and well-being, etc. A good vision also incorporates well-defined roles for the members of the community and the organization, for example, local, state, and federal government agencies, citizens, business, etc. Each organization has an appropriate function that enhances and supports the functions of the others. The regulator must take ownership of the community's vision so the regulatory activity has a context and is goal-oriented.

Principle Number 2: Build Trust Among Public Agencies at All Levels and Between the Public and Private Sectors

Trust is a commodity that has conspicuously ebbed from the scene in the regulatory process. Trusting means letting go, allowing things to happen outside controlling spheres. One of the lessons we can glean from the collapse of the Communist world is that trying to control too much destroys natural community and interpersonal bonds.

In the State of Maryland, a number of relatively new environmental programs are working using elements of this new process. An example of this is the statewide erosion and sediment control program. This program is one that works very successfully in Prince George's County. The state has primary responsibility for the regulation of erosion and sediment control in the construction process. It also has the authority to delegate that responsibility to each county for two years at a time. The sediment control statute requires the Maryland Department of Natural Resources to set standards and allows each county with delegated authority to run the program consistent with the standards, subject only to state review. Of course, if the county fails to adhere to the standards, the state takes

away the delegated authority and the county loses control over its development process. With the counties managing the process and the state auditing it, there is a much greater motivation on the part of each to be successful.

Maryland runs similar programs in storm water management and in the state-mandated land use program for the Chesapeake Bay known as the Chesapeake Bay Critical Area Program. The Chesapeake Bay Critical Area Program is managed by a commission made up of state and local officials and citizens. The commission sets the standards and its membership ensures a process of local participation that prevents the program from becoming a *State Land Use Program*. This process also ensures there is respect for how things are done locally. The local governments are trusted to do the enforcement, and they are in the best position to handle it.

Regulatory programs should be written without loopholes, but with room for interpretation. Regulatory officials should be responsible for allowing for extenuating circumstances and to make appropriate exceptions. Regulators must break out of the mold of monolithic interpretation and trust in their own professional judgment and, of course, be allowed to do so. Trusting means letting go! The regulatory system must allow those who can be trusted to work unimpeded. The system must also fall swiftly on those who would take unfair advantage of the trust. The system should reward the person who protects the environment and should not punish all as if no one can be trusted. Another aspect of this kind of regulatory posture is that things may not be done the way a regulator might prefer, but that does not mean they have been done wrong. Diverse solutions can be accommodated. Building trust means being trusted. Trusting, being trusted, and being free to let go can be parts of the vision. This connection introduces us to the next principle, *connectedness*.

Principle Number 3: Respect the Connectedness of Everything in Natural and Socioeconomic Systems

One of Barry Commoner's laws of nature is: "Everything is connected to everything else." The theme of connectedness in one that is heard everywhere in these times. People know that what they do in their homes affects the global environment. Two examples are the depletion of stratospheric ozone because of the widespread use of CFCs and the concept of global warming from the intensive use of fossil fuels. Connectedness goes beyond natural systems; and, because human beings are in reality part of nature, the things we do are also connected to natural systems. In order to plan for a truly healthy and diverse environment, the universal connectedness of things in nature and of natural systems must be respected. Regulators must recognize that this connectedness extends to socioeconomic systems, as well as the connectedness of socioeconomic systems to natural systems. They must take responsibility for their role in determining the consequences of outcomes. Just as business people must understand how their moneymaking activity affects environmental systems, regulators must grasp how their resource protection activities affect socioeconomic systems and take responsibility for that.

In the State of Maryland, the Office of Planning, the Department of the Environment, the Department of Natural Resources, the Department of Agriculture, and the seven counties in the Patuxent watershed are using U.S. Environmental Protection Agency funds to prepare a watershed-wide guidance document. This document will address water quality and habitat concerns in the Patuxent River; each county will be able to provide for its own economic and cultural well-being according to its own vision and goals.

Principle Number 4: Have Sensitivity to the Needs of the Regulated Community, Particularly with Respect to Market and Economic Forces

Visualize a community with a healthy, functioning ecosystem—terrestrial and aquatic and further—and here's the revolutionary idea—businesses are fantastically successful. Visualize environmental regulators who see their goal as protecting the environment and making business projects financially profitable. This sounds like a revolutionary idea, but doesn't it make a lot of sense? One way to help businesses be successful is by saying *no* early in the process so heavy investment is prevented. It is also important to say *yes* as early in the process as possible. The worst thing for the business investor is to be strung along

when, in fact, the regulator doesn't want to say *yes* and hasn't the conviction to say *no*. Government officials should be helping businesses to accomplish their economic goals for the benefit of the community. This means working with people and helping them, when appropriate, to find a way to succeed.

We all have a role in our community. Environmental regulators have the role of protecting environmental systems. People in business have the role of creating wealth. Both sectors must help each other succeed in their role. Business people should, of course, be sensitive to the environmental systems when they design and build their projects. *And* environmental regulators must be sensitive to social and economic issues when they review these projects or establish policies for their regulation. Both should understand the vision and use it to assist them in preparing their groundwork.

Principle Number 5: Use Good Judgment, Assess the Risks, Evaluate Outcomes, Make Appropriate Changes

It is imperative for us to know if we are getting the desired results in environmental protection, in economic activity, in the cultural identity of the community, in the health and well-being of the people. Using good judgment means accurately assessing risks and then understanding which are appropriate to take. It means being objective about data and making changes when the data show that results are not what has been expected. Also we need to judge if we are living into the vision and if the vision needs to change.

Using these principles, agencies, managers, and employees become focused on larger goals and begin to understand how they affect and are affected by other players in the process. They become motivated to cooperate and share in the accomplishments of the organization. This philosophy, which is also being tested in planning for the Patuxent River watershed in Maryland, can be the heart of successful implementation of the "watershed approach."

Conclusion

Building support among the participants in the regulatory process builds trust among them too. Understanding the connectedness of the roles also builds trust and strengthens the vision. Seeing the connectedness in nature can help us respect the connectedness in human systems and cultivate sensitivity to the forces that constrain people's actions. Basing regulatory action on that sensitivity builds trust and enhances the vision. Good judgment requires that we stop doing things that don't work, and that we evaluate how well we are living the vision and make appropriate action based on that evaluation.

The Economics of Silvicultural Best Management Practices

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Several papers have discussed the economics of implementing best management practices (BMPs) from the cost side of the equation, with no attempt to develop the benefits side of the equation for the landowner or operator. Ellefson and Miles (1984) reported on the costs of implementing skid trails, landing design, seeding and fertilizing skid trails and roads, waterbars, broad-based dips, and buffer strips and of installing culverts to the timber purchaser. Hickman and Jackson (1978) used linear programming to evaluate the economics of timber rotations and species constrained by on-site erosion. Dykstra and Froehlich studied costs of filter/shade strips. Benson and Niccolucci (1986) analyzed the stumpage costs of implementing road, log hauling, skidding, and slash disposal BMPs.

There are benefits to the landowner and operator for implementing BMPs. It is not all cost! The basic principle in forestry is: those things done to maintain or improve water quality are often the same things done to maintain or improve soil productivity (Dissmeyer et al., 1987). It is through maintaining or improving soil productivity that landowners derive benefits in terms of increments of induced outputs of timber, forage, wildlife, recreation, etc. over implementing poor soil and water management. The national effort by the U.S. Department of Agriculture (USDA) Forest Service developed the models and methods for evaluating increments of induced outputs and demonstrated them through 16 examples (Dissmeyer et al., 1987).

Soil and water are the basic resources. They are essential to the production of all forest and range products and services. The amount of goods and services produced depends directly on the manner in which soil and water resources are managed, conserved, and used.

These resources and services have economic value, which vary to the extent they are in limited supply and meet human needs. Through specific examples, the USDA Forest Service project identified incremental outputs and values of induced goods and services attributed to investments in soil and water resource management. Generally, the project emphasized comparing the value of goods and services produced or conserved with costs incurred.

Methods

The project developed five matrices to estimate economic benefits from soil and water resource management in five emphasis areas: timber, forage, fish, enhanced water, and road construction and maintenance (Dissmeyer et al., 1987). The procedures can be applied to recreation, wildlife, and other soil and water dependent resources.

To illustrate the matrices, a simplified timber matrix is presented (Table 1). Literature and field data are used in the analysis. Two southern soil- and water-related timber management practices are compared: site preparation for tree planting using disking versus chop and burn practices (Column 1).

Disking usually follows shearing and windrowing, which removes nutrients and topsoil to windrows, often reduces soil productivity, and yields a significant sediment to the stream. Chopping followed by a cool burn leaves more nutrients in place, better maintains soil productivity, and

Table 1. Simplified timber matrix

(1) Soil & Water related practice	(2) Stocking level (%)	(3) S&S growth (m)	(4) P&S growth (m)	(5) Height growth curves	(6) Growth & yield tables	(7) Induced res. output	(8) Economics B $	C $	B/C	IRR %
Site Prep.										
Disking	%	Height	Height	R	Y_A					
Chop & burn	%	Height	Height	R	Y_B	$Y_B - Y_A$	B	C	B/C	%

yields little sediment. To evaluate timber output differences between treatments, the following information and analysis tools are needed.

The type of site preparation can affect initial stocking levels (column 2). Stocking levels at the end of a timber rotation can be predicted with existing relationships.

Seedling and sapling height growth (column 3) and pole and sawtimber height growth (column 4) are often affected by site preparation treatments. By using growth models, rotation heights can be estimated with models (R) from early stand heights (column 5).

Estimated stocking levels and rotation stand height can be entered into growth and yield tables (column 6) to estimate wood volumes at the end of the rotation. The estimated wood volume for disking is Y_A, while chop and burn should yield Y_B. Assuming disking produces less wood than chop and burn, the induced timber output from better soil and water resource management with chopping is $Y_B - Y_A$ (column 7).

The increment of induced timber volume ($Y_A - Y_B$) has a stumpage value that is discounted to a net present worth or benefit (B) in column 8. The cost of site preparation and management over the rotation is adjusted to present cost and the difference in treatment costs is (C) in column 8. With these data, benefit/cost ratios (B/C) and internal rates of returns (IRR) can be computed (column 8).

Examples of BMP Economic Evaluations

The following three examples demonstrate the application of the concepts, matrices, and analytical procedures discussed above and in the project report (Dissmeyer et al., 1987). These three examples are limited to timber production and savings in road maintenance costs. The examples were developed for site specific situations and the results should not be extrapolated to other settings. The examples are brief, yet allow the reader to follow the logic and procedures used.

Example 1. Road Construction and Maintenance

Problem: The main haul road to a timber sale was built across problem soils where the cutbanks yield excessive runoff and erode easily. The volume of runoff from the cutbanks erodes through the road surface and subgrade. The road will be used to haul timber periodically over the next 20 years. To maintain access, repair of the road surface and subgrade will be needed every 3 years. BMPs were not used in the road location, design, or construction.

Solution: The road should have been constructed using the following BMPs: (1) midslope terraces in cutbanks, (2) water diversions above cutbanks, and (3) cutbanks seeded, fertilized, and mulched.

Rationale: Actual repair costs at 3-year intervals are compared to the costs of BMPs and savings in maintenance costs over a 20-year period.

Economics: Current situation with maintenance cost at 3-year intervals. Repair costs are:

Equipment costs (truck, frontend loader, and bulldozer, plus operators)	$365
Materials (subgrade fill and surface gravel)	122
Work supervision	40
Total repair costs	$527

The discounted value of six maintenance costs over the 20-year expected life of the road is $2,137, using a discount rate of 4 percent.

The alternative is installing the BMPs to control runoff and revegetate the cutbanks, which will eliminate the need for heavy maintenance every 3 years. The costs of technical assistance and BMPs:

Labor to construct mid-slope terraces and water diversions above the cutbanks	$780
Materials to revegetate cutbanks	120
Cost of technical assistance	300
Total cost	$1,200

Considering the $2,137 saved as the benefit of spending $1,200 more at the time of construction:

1. The present net value is $937.
2. The benefit/cost ratio is 1.78 to 1.00.
3. The internal rate of return is 11.2 percent.

Example conclusion: The additional cost to install BMPs at the time of road construction would have been strongly justified on economic grounds.

Example 2. Site Preparation BMPs and Timber Growth and Yields

Problem: The way a site is prepared for tree planting can significantly affect sediment yields, soil productivity, and timber growth and yields by exposing and compacting soil, and by removing litter, topsoil, and nutrients.

Rationale: Shearing and windrowing or bulldozing and windrowing are common site preparation practices in the South. Dissmeyer (1986) summarized research on impacts of various types of site preparation on timber growth and yields. Research has demonstrated that shearing and windrowing can reduce height growth at the end of the rotation by as much as 4.3 meters, compared to soil conserving practices. For this example, shearing and windrowing will be compared to chopping and light burning, and the height difference is assigned a conservative 1.5 meters (Patterson, 1984). The average erosion rate for chopping and burning will be approximately 30 to 50 percent of the rate for shearing and windrowing (Dissmeyer and Stump, 1978).

Economics: Patterson (1984) used a site index of 21.3 meters for chopping and burning (Table 2), and 19.8 meters for shearing and windrowing (Table 3). A growth and yield model estimated differences in timber production for a 36-year rotation with 1,480 trees per hectare. Stumpage prices used were $2.76/m^3 of pulpwood and $41.61/m^3 of sawtimber.

Example Conclusions: Implementing site preparation BMPs by favoring chopping and light fire overshearing and windrowing reduces sediment and better maintains soil productivity and timber production. The landowner will get a greater return on his investment by investing $124 less per acre with chopping and burning and increase the present net value of timber by $318 per hectare, compared to shearing and windrowing. Employing chopping and burning yielded larger trees and more valuable products.

Example 3. Skid Trail Rehabilitation

Problem: Implementation of skid trail rehabilitation BMPs is viewed as a cost only by landowners. This example demonstrates the value of mitigation BMPs by recouping soil productivity on intensively disturbed soils in skid trails. Timber yield from trees growing in primary skid trails and roads is severely reduced compared to adjacent undisturbed soils. Soils within skid trails are severely compacted, limiting soil moisture availability and root development. Soil nutrients are removed during skidding

Table 2. Site preparation with chopping and light burn

Year	Description	Cost /ha	Income /ha	Wood Volume /hectare
1984	Site prep. & planting cost	$296		
1999	Thinning income (pulpwood)		$252	91.2 m^3
2010	Thinning income (pulpwood) & (sawtimber)		526	47.4 m^3 & 9.5 m^3
2020	Final harvest income (pulpwood) (sawtimber)		2,417	22.4 m^3 & 56.6 m^3

Internal rate of return: 8.1 percent.
Present net value (at 4 percent): $622/ha.
Benefit/cost ratio (at 4 percent): 3.1 to 1.0.

Table 3. Site preparation with shearing and windrowing

Year	Description	Cost /ha.	Income /ha.	Wood Volume /hectare
1984	Site prep. & planting cost	$420		
1999	Thinning income (pulpwood)		$180	65.3 m^3
2010	Thinning income (pulpwood) & (sawtimber)		331	85.9 m^3 & 2.2 m^3
2020	Final harvest income (pulpwood) (sawtimber)		2,069	31.3 m^3 & 47.6 m^3

Internal rate of return: 5.8 percent.
Present net value (at 4 percent): $304/ha.
Benefit/cost ratio (at 4 percent): 1.72 to 1.0.

and in the construction of skid roads. Skid trails and roads can be significant sources of sediment.

Solution: Employ BMP rehabilitation treatments, which usually include soil ripping, waterbarring, seeding, fertilizing, mulching where needed, and in this example, followed by tree planting.

Rationale: Wert and Thomas (1981) found the volume growth of 42-year-old Douglas fir (*Pseudosuga menziesii*) in primary skid trails was reduced by 74 percent, compared to trees growing in undisturbed soil. Loblolly pine (*Pinus taeda*) seedling survival and early growth in compacted, primary skid trails was adversely affected (Hatchell et al., 1970). Tilling and fertilizing heavily compacted skid trails and landings resulted in seedling growth through age 4 as being close to the growth occurring on undisturbed soils (Hatchell, 1981) and at age 12, the trees were essentially the same height.

Growth differences observed during the first 5 to 10 years of stand development on upland sites will persist through a pulpwood rotation and likely to a sawlog rotation (Dissmeyer, 1986). If loblolly pine heights in rehabilitated skid trails and undisturbed soil are essentially the same at ages 4 and 12, then they should be essentially the same at the end of a sawlog rotation.

Economics: The economics of primary skid trail and landing rehabilitation can be approximated using data by Wert and Thomas (1981). Observations of shortleaf pine and hardwoods in the South exhibit similar growth differences between skid trails and undisturbed soils. Benefits from skid trail and landing rehabilitation for hardwood (*Quercus* sp.) and shortleaf pine (*Pinus echinata)* on site index 18.3 meters and 21.3 meters (base 50 years) sites are estimated (Table 4).

Sawlog rotations of 60 and 70 years were used. Table 4 shows the expected volume of timber per hectare and the value per cubic meter.

A growth loss of 74 percent (Wert and Thomas, 1981) was used to estimate timber volume on skid trails. The estimated timber volume on skid trails is 26 percent of the volume on undisturbed soil (Table 4). To be conservative, it was estimated that only 75 percent of the timber volume loss would be regained by skid trail rehabilitation.

The present net value of hardwood timber recovered is a minus $592 per hectare, while the value of shortleaf pine timber is a positive $524 per hectare skid trail rehabilitation. The benefit/cost ratio for hardwood is 0.34 to 1.0, and for shortleaf pine it is 1.58 to 1.0.

Example conclusions: Economic evaluations of soil rehabilitation treatments can help determine where implementation of BMPs is cost-effective. Investments in skid trail rehabilitation, including tree planting,

Table 4. Economic benefits of skid trail rehabilitation BMPs

		Timber Type	
	Units	**Hardwood**	**Shortleaf Pine**
Rotation	Years	70	60
Harvest volume per hectare	Cubic m	301	420
Value per cubic meter	1986 $	$28.57	$64.29
Total value of timber per hectare for uncompacted soil	1986 $	$8,600	$27,000
Timber volume per hectare on skid trails (26% of uncompacted soil)	Cubic m	78	109
Timber volume lost per hectare of skid trail	Cubic m	223	311
Cost per hectare of skid trail rehabilitation plus tree planting	1986 $	$900	$900
Timber volume recovered (75% of loss)	Cubic m	167	233
Value of timber volume recovered	1986 $	$4,771	$14,980
Internal rate of return	Percent	2.4	4.8
Present net value (at 4 percent)	1986 $	- $592	$524
Benefit/cost ratio (at 4 percent)		0.34:1	1.58:1

in moderately high-valued shortleaf pine forests contributes significantly to timber production and is a financially sound investment. In relatively low-value hardwood forests, skid trail rehabilitation may not produce a positive financial return to the landowner from timber production alone. By treating skid trails as wildlife food plots, the combination of hardwood timber and wildlife values may make the investment financially sound.

Conclusions

Implementation of BMPs can be a financially sound investment for the landowner and operator in many but not all situations. The examples presented focused on returns in timber production, and with the addition of other increments of resource outputs the investments can be made more attractive. The methodology for evaluating the economics of BMP implementation is available and should be used by policy makers, land managers, and operators.

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Preservation and Restoration of Wetlands: The Challenge of Economic-Ecological Modeling on a Watershed Basis

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Efforts to protect the environment and conserve natural resources and biological diversity increasingly require integration of economic and ecological considerations in land use planning and policy formulation. Our goal was to develop an interdisciplinary approach to integrate ecological and economic concerns in watershed planning. Agricultural economists, wildlife ecologists, geographers, and foresters have been working on ecological and economic evaluation of land use scenarios designed to preserve, restore, and maintain natural ecological communities in a rural watershed in southern Illinois. Our challenge was to provide a planning framework for sustainable development of the local and regional economies that is compatible with protection and restoration of biodiversity. We applied the biosphere reserve concept that includes a core area (ecological preserve), a buffer area, (watershed surrounding the core), and the region outside the bioreserve.

Our study area was the Cache River Watershed, encompassing a 1,944-square-kilometer area of five southern Illinois counties (Figure 1). The Cache River lies at the juncture of four major physiographic provinces: Central Lowlands, Ozark Plateaus, Coastal Plain, and the Interior Low Plateaus. Biodiversity is high; 100 plants and animals on the Illinois threatened and endangered species list occur within the

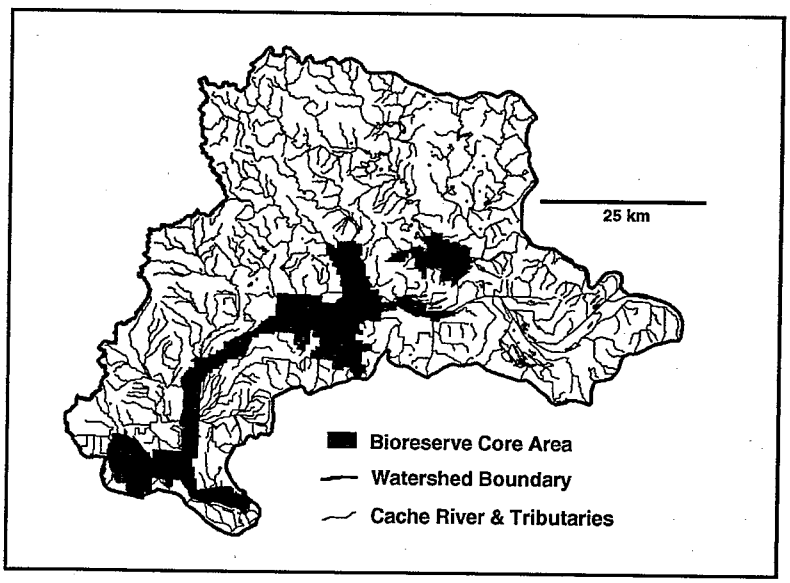

Figure 1. The Cache River Watershed in southern Illinois and boundaries of the Cache River Bioreserve core area, including current state and federal holdings and the acquisition area for Cypress Creek National Wildlife Refuge and joint venture areas.

watershed. The Cache River basin supports 10 globally rare or endangered species and ecological communities; the area also is part of a regional economy.

Health of the human community and the Cache River ecosystem is closely linked to how natural and human resources are used in this rural area. The new Cypress Creek National Wildlife Refuge (NWR) on the Cache River supports efforts by The Nature Conservancy, Ducks Unlimited, Inc., and the Illinois Department of Conservation to protect and restore unique ecological communities, particularly forested wetlands and cypress-tupelo swamps within the bioreserve core (Figure 1). Agricultural and other activities within the surrounding buffer area have profound effects on the human services and ecological functions that natural communities within the core area provide. However, purchase of the entire watershed by joint venture agencies is neither feasible, nor desired by the local populace. Challenges of economic development and natural community restoration in the Cache River region are to (1) identify economic development opportunities in the watershed that will replace or enhance economic activity after establishment of the bioreserve and (2) propose alternative land use scenarios outside the core area that are ecologically compatible with preservation of natural communities throughout the watershed.

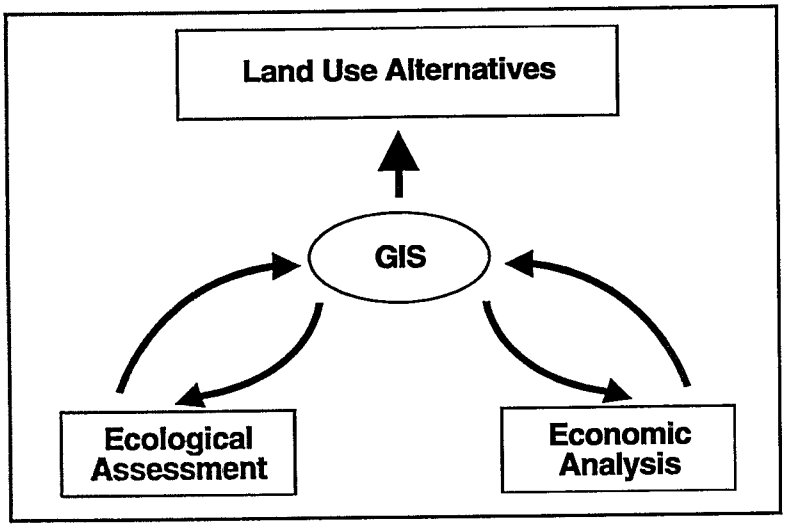

Figure 2. A conceptual model illustrating a general approach to model and evaluate economic and ecological impacts associated with land use changes in a rural watershed. Geographic information systems (GIS) provide the means to link economic and ecological analyses with land use planning.

Approach

Benefits and costs of changing land use patterns were projected based on ecological and socioeconomic perspectives. Our work provides a replicable framework to integrate socioeconomic and ecological parameters, and to model impacts associated with land use changes in an economically sparse rural watershed. Our approach applied geographical information systems (GIS) to simulate and evaluate ecological changes resulting from land use changes, and economic modeling using a hybridized regional input/output model (IMPLAN) (University of Minnesota, 1989). Three scenarios were evaluated: (1) natural community restoration and wildlife habitat development within the core area, (2) establishment of filter strips along streams outside the core area to control sediment input to the Cache River, and (3) conversion of highly erodible land from crop to forage production in the buffer area. Land use scenarios were compared as to their relative ecological benefits, and their impact on local and regional economies. Using our approach, economic and ecological constraints can be imposed and evaluated in an iterative process that will lead to formulation of a watershed management plan to accomplish socioeconomic and ecological objectives (Figure 2).

Methods

Current land use (forest, row crop, forested upland, herbaceous upland) was determined from an August 1991 LANDSAT 5 satellite scene. Wetland communities and riparian corridors were identified and mapped by merging National Wetlands Inventory (NWI) and Digital Line Graph (DLG) data with the satellite image. ARC/INFO and Map and Image Processing System (MIPS) GIS software was used to summarize land use and wetland habitat composition over the entire watershed, within the core area, and within 90-m stream buffers (filter strips) outside the core area. These data were converted to coefficients for input to a regional input-output (I/O) economic model. Ecological responses anticipated from implementing the three land use scenarios were qualitatively evaluated and compared based on available information for the Cache River Watershed. We focused on control of sediment input to the lower portion of the watershed and on frag-

mentation and connectivity of upland forests and swamps that provide habitat for native flora and fauna.

Regional I/O analysis (Miller and Blair, 1985) was used to assess economic impacts of land use changes. We used regional data derived from surveys, empirically based agricultural budgets, sales tax data, and other sources to hybridize the IMPLAN model with technical coefficients appropriate for the region. Technical coefficients reflected productive relationships among sectors within the region, and the extent to which buyers of intermediate and final goods and services were willing to purchase regionally produced goods.

We evaluated economic impacts of a reduction in row crop acreage, increased nonresident demand for recreation services, response of local businesses to changes in recreation demand, and the capacity of the economy to meet a larger proportion of demand for recreation services. These issues are examined in a spatially diffuse and sparse rural economy, making it difficult to measure the strength of secondary economic impacts (Beck et al., 1990). Primary and secondary impacts resulted from net transfer of land from agricultural production to production of wildlife and recreation services, through establishment of a National Wildlife Refuge in the core area.

Economic impacts were developed for 405-hectare (ha) units to assess effects of filter strips established to control sedimentation. These units included cropland converted from row crop production to production of forage crops. Recreation impacts were based on conversion of 15,176 ha to public recreational uses, with 9,470 ha diverted from agriculture. Analysis assumed that residents will expand their economic activity over a 15-year period to provide recreational services required by visitors. Recreation and tourism effects of a visitor center and development of private hunting clubs surrounding the refuge also were considered. Impacts on final demand, income at place of work, employment, and human population of the watershed were estimated after 5, 10, and 15 years.

Results and Discussion

Ecological Assessment

The Cache River Watershed currently includes 49,085 ha of upland forest and 14,290 ha of forested wetland and swamp (25 and 7 percent of the watershed, respectively). Planned land acquisitions and habitat restorations in the core area could eventually add about 9,000 ha of lowland and upland forest, prairie, and wetlands to the watershed. About 10 percent of Cypress Creek NWR will be retained in row crop agriculture (Roelle and Hamilton, 1992). Natural community restorations within the core area will provide the greatest ecological and recreation benefits of the three land use scenarios. However, altered surface water drainage patterns have disrupted natural hydrologic regimes in the watershed. Channelization of major tributaries and diversion of streamflow from the upper watershed directly to the Ohio River causes sediment deposition in riparian wetlands associated with the Lower Cache River. Sedimentation and altered hydrologic regimes have severely degraded cypress-tupelo swamps and other wetlands that remain in the lower watershed. Restoration of natural hydrologic regimes and control of sediment input to the Lower Cache River are essential components of ecological restorations.

Establishing riparian filter strips and converting erodible cropland to permanent herbaceous cover in the buffer area are projected to have minimal impact on sediment deposition in swamps within the core area. Converting cropland to filter strips would add about 12,144 ha of herbaceous or wooded vegetation cover to the watershed outside the core area. Filter strips would enhance the biological integrity of riparian corridors, provide wildlife habitat, and connect fragmented riparian wetlands.

Sediment input to the Lower Cache may originate largely from bed and bank erosion in tributary streams. Much of this sediment was deposited from agricultural runoff that occurred when the watershed was more extensively farmed, and before soil and water conservation practices were widely implemented (Davie, 1991). Consequently, establishment of filter strips and conversion of erodible cropland to forage production likely will only marginally reduce sediment input to the Lower Cache River. Restoration of channelized streams to their original channels may be more effective in reducing sedimentation by slowing flows, thereby reducing bed and bank erosion and allowing sediment to settle before entering core area swamps. Increased streamflow from the upper watershed to the

Lower Cache River may be necessary to transport some of the sediment previously deposited in swamps, and to restore natural hydrologic regimes.

Economic Impacts

Assuming phased in development of necessary infrastructure and increased entrepreneurial activity over a 15-year period, there would be an increase of $714,000 in final recreation demand by year 5, $1.3 million by year 10, and $3.7 million by year 15. Total place of work income would increase by $421,000 in year 5, $649,000 in year 10, and 1.8 million in year 15. Employment in year 5 would increase by 26 jobs, in year 10 there would be 52 additional jobs, and by the end of year 15 there would be a total of 129 new jobs in the region. Increased economic activity would result in a gradual population increase of 452 persons by year 15. These effects are not large, given the size of the overall economy in the five-county region. However, recreation development would supplement the region's chronically poor level of economic performance. The economic changes "twist" the regional economy, resulting in a more diversified, service-based economy.

Although filter strips may have some indirect long-term recreational benefits, these were not explicitly considered in the analysis. Improvements in water quality and wildlife habitat and their recreational benefits were implicit in projections used to determine overall recreation impacts. Shifting cropland from row to forage crop production in filter strips resulted in substitution of higher value crops (e.g., corn, soybeans, vegetables) with lower value crops (e.g., alfalfa or tame hay). For each 405 ha converted to filter strips, final demand will fall by $58,000, employment will decrease by one job, and population will fall by four.

The Cache River region lacks the infrastructure necessary to adequately supply the demands of nonresident visitors to the core area. Furthermore, the regional economy lacks the capacity to supply a high resident demand for goods and services. Consequently, the degree of interconnection among economic establishments in the region is low. The more sparse a region's economy is for a given level of change in a base sector (such as recreation), the less other business and household establishments are affected.

Conclusions

Using ecological and land use analyses in conjunction with I/O modeling provides a useful basis for assessing effects of land use changes designed to protect ecological resources and to diversify a regional economy. Economic results combined with iterative assessment of ecological effects of land use changes provides a methodological framework for watershed planning and predicting impacts of land use change on the regional economy. Projected changes in the economy can be used to determine whether anticipated changes are acceptable to the human community. Concurrent ecological assessments provide analyses of the impact of land use changes on the quality of critical ecological resources. Results can be used to modify proposed land use changes so that ecological benefits and economic gains are maximized. Land use alternatives in the buffer area can be designed to provide the greatest ecological benefit. Our framework also provides a basis for assessing ecological and economic impacts of public policies that might be implemented within a predominantly rural watershed.

Acknowledgments

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Santa Ana River Reuse Optimization Model

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Santa Ana Water Reuse Conceptual Study

The feasibility and methods of marketing water for reuse in the Santa Ana River Basin (Basin) were recently studied by the Santa Ana Watershed Project Authority (SAWPA) in Southern California. The Santa Ana River Reuse Optimization Model (Model) was developed during the study to evaluate the interrelationships, trade-offs, and economic impacts of reuse projects within the Basin. SAWPA's goals were to maximize water reuse opportunities in the Basin and to maintain cooperative working relationships among the SAWPA agencies. This optimization model is now available for more detailed analyses of reuse in the Basin.

The Model incorporated other studies by SAWPA member agencies, water retailers, and dischargers to the Santa Ana River. These included projects for expanded reuse, desalting of ground water, remediation of contaminated ground-water basins, wastewater treatment and discharge, storm water quality analysis, water supply, conjunctive use of surface and ground-water supplies, wetlands enhancement, and export of water. Many of the previous studies were conducted without coordination between the agencies. The basinwide impacts of all these projects were not always addressed in each study and can be hard to quantify.

Background

SAWPA is a joint power agency charged with implementing a 1974 water quality plan (Plan) for long-range management of water resources in the Basin. SAWPA member agencies are the Chino Basin Municipal Water District (CBMWD), the Eastern Municipal Water District (EMWD), the Orange County Water District (OCWD), the San Bernardino Valley Municipal Water District (SBVMWD), and the Western Municipal Water District (WMWD).

The Santa Ana River flows through these five jurisdictions and into the Pacific Ocean. Water supplies in the basin are surface water, ground water, and imported water. The Basin is divided into the Upper Basin, those agencies above Prado Dam (CBMWD, EMWD, SBVMWD, and WMWD), and the Lower Basin, the agency below Prado Dam (OCWD). Management of the local water supplies is constrained by legal judgments and interagency agreements that specify base flow quantities and quality at key locations on the river (USBR, 1989), the sources of flow to meet these requirements, and the rights to stormflows reaching Prado Dam.

In the Lower Basin (below Prado Dam), the river supplies water to Orange County by ground-water recharge. Recharge activities have increased as the quantity of treatment plant effluent discharged to the river from the Upper Basin (above Prado Dam) has grown. Riverflows increased from 49,000 acre-feet per year (ac-ft/yr) in 1980 to 125,000 ac-ft/yr in 1990.

The Upper Basin agencies have been required to substantially improve the quality of wastewater effluent to meet plan goals. New waste discharge requirements that are

potentially more stringent will drive local wastewater dischargers to higher levels of treatment. Current regulatory activities, such as the Basin Plan for TDS and Nitrogen Control and the California Inland Surface Waters Plan (WRCB, 1991), could significantly affect the treatment processes, the effluent water quality, and the economics of reuse in the Upper Basin. As the rules for stream discharge are made more stringent, reuse of the effluent becomes a competitive alternative to discharge. However, increased water reuse in the Upper Basin could reduce the river flows available for riparian habitat and groundwater recharge in the Lower Basin.

Study Approach

The Basin is a complex, interrelated system of water supplies with varying water quality, water demands, and water quality needs. It is complicated by the range in goals of the member agencies, by current and anticipated regulatory requirements, by water rights and other legal constraints, and by environmental factors of the river. SAWPA's Santa Ana River Water Reuse Conceptual Study used the Model to organize data, analyze the cost-effectiveness of reuse projects, and illustrate the interrelations between the ongoing analyses. The Model, based on linear programming, can systematically evaluate all feasible reuse alternatives to identify the combination of projects to minimize the cost of effluent reuse and disposal in the Basin.

The study goal was defined by a mathematical equation (objective function) developed from discussions with SAWPA and the member agencies. The objective function for this study was to minimize the cost of meeting water demands and disposing of wastewater effluent. This function is subject to quantity and quality constraints that force the optimal solution to meet regulatory standards, institutional requirements, and water rights constraints; satisfy all water demands; and account for all effluent so that it is either used to meet a demand or discharged. The Model also demonstrates the sensitivity of the optimal solution to changes in project costs or in the quantity constraints. The sensitivity analysis also focused future engineering analyses on the projects or alternatives that are most important (or could become important) with only minor cost changes.

The study approach used data provided by the SAWPA member agencies without modification. The cost data varied considerably in level of accuracy, and can at best be described as conceptual-level data. However, these costs did provide a good basis for comparing alternatives. The optimization approach allows such preliminary data to be used without reducing the value of the solution. This is possible due to the inherent sensitivity analysis that illustrates whether the optimal combination of reuse and river discharge alternatives are affected by changes in these data values.

This preliminary analysis, although limited in depth and short in duration, produced a tool and a framework for future analyses. The optimization analysis was intended to focus on relatively short-term decisions, and so focused the study on costs and quantity constraints for the year 2000.

Model Overview

The Model was designed to evaluate opportunities for wastewater reuse in the basin. The Model uses information on reuse demands, sources, and costs, along with information on river base flow and quality from an existing surface flow model of the Basin (JMM, 1991; Wildermuth, 1991). These data are used in the Model to select reuse projects that minimize the total cost of water supply and wastewater discharge. The Model links sources, demands, and discharges with the flow and quality of river water. The Model then reports the volume and cost of wastewater discharged, by treatment plant or agency; the volume and cost of wastewater reused, by treatment plant, agency, or demand area; and the flow and quality (total dissolved solids (TDS) and total inorganic nitrogen (TIN)) by reach of the river.

Projects were assumed to be constructed in 1994 and fully operational in the year 2000. All design and construction costs were escalated to the year 1994, and all flow and operations and maintenance (O&M) costs were projected to the year 2000. The cost for each project was then expressed as a constant unit cost per acre-foot ($/ac-ft), which implicitly imposed a linear cost function. As a result, any projects that were scaled for flows significantly different than the predicted levels in year 2000 could still be compared on a consistent basis ($/ac-ft).

Wastewater was assumed to be completely utilized by one of the demand areas in the Model—either conveyed directly from the treatment plant to a demand area (for direct nonpotable use or for ground-water recharge) at a cost, or discharged to the river, also at a cost. Water that flows to the river was adjusted for downstream losses or gains and was assumed available to the Lower Basin for ground-water recharge. The wastewater is valuable in any of these reuse activities because it allows the SAWPA member agency to avoid purchasing an alternative supply (typically, imported water from Metropolitan Water District of Southern California (MWDSC)).

Imported water has become increasingly difficult to obtain, especially during the summer, so the Model can restrict the availability of imported water to simulate future shortages. To maintain feasibility when a shortage exists, the Model allows a demand area to select shortage as a way of meeting (reducing) demand. Water agencies and users bear the cost associated with a water shortage, which was assumed to be 1.5 times the normal water rate. In other words, the value of having reclaimed water available during a shortage was assumed to be 50 percent higher than the value of using that water under full supply conditions.

Model Structure

The Model is designed to optimize the reuse of wastewater; this does not necessarily mean the greatest possible reuse of wastewater, but rather the most cost-effective reuse. The Model balances the cost of reusing wastewater against the alternative costs of discharging it and buying imported water to meet demands.

Two different objective functions were within the Model: the Upper Basin Model and the Full Basin Model. Both minimized the combined cost of wastewater disposal, alternative water purchase, wastewater reuse, and water shortage. The difference between them is that the Upper Basin Model incorporates only the costs and water values to Upper Basin districts, while the Full Basin Model considers the value of the water to all member agencies, including the Lower Basin. The Model was solved separately for each objective. The Upper Basin optimization showed the minimum-cost solution for the areas generating the wastewater if they have no incentive to provide more than the minimum flow to the river required by legal judgements and agreements. The Full Basin optimization showed the overall best solution if the costs to all SAWPA member agencies are considered.

The operations of the Upper Basin agencies must meet certain minimum flow and quality requirements. The optimization Model is designed to calculate annual flow, average TDS, and a preliminary estimate of average TIN for different segments of the river. The river reaches in the optimization Model are directly related to the reaches in the surface flow model used for setting Basin Plan objectives, though the two models are not formally linked. Data and results from the surface flow model used for the adopted Basin Plan were used as inputs to the Model. In addition to using equations that calculate load and flow at each river reach, the Model also restricts the load and flow at certain reaches, based on court judgments, agreements, and water quality plans described earlier.

The Model does not consider the full water demand of the agencies within SAWPA, but rather only those areas and demand categories that could potentially use reclaimed water. Demand categories include direct, nonpotable use (such as crop or landscape irrigation) and indirect use through ground-water recharge. All water flowing past Prado Dam was assumed to be available to the Lower Basin for ground-water recharge.

For the defined areas of potential reuse, the Model forces total reuse demand to be met by one of three ways: reuse the wastewater, purchase water from the specified alternate supply, or suffer a shortage. For each wastewater source, the Model restricts all wastewater flow to either discharge or reuse.

The Model was written and solved using the GAMS (General Algebraic Modeling System) mathematical programming language, a tool for formulating and solving large optimization problems. Data entry, data manipulation, mathematical description of the model equations, model solution, and processing of model output can all be done with a single ASCII computer file. The code is portable across many computers, including IBM-compatible desktops, UNIX workstations, minicomputers, and large mainframes. GAMS solves nonlinear models by using the well-known

MINOS 5.2 solver, developed at the Stanford Systems Optimization Laboratory (Murtaugh and Saunders, 1987). The Model was solved on a Compaq 486-33. The base scenario, including data manipulation and solution for each of the two objectives, ran in under 30 seconds.

Results of Initial Optimizations

Two different objectives were defined for the optimization: one objective included the value of wastewater to all SAWPA member agencies (Full Basin); the other objective focused on the four Upper Basin agencies (Upper Basin). There was a significant difference between the reuse projects recommended by the Full Basin Model and those recommended by the Upper Basin Model, which underscores the importance of appropriately defining the project beneficiaries.

The base cases assumed that a full supply of imported water was available, and that the Lower Basin could recharge a maximum of 200,000 ac-ft/yr. The results discussed below are best used to show the potential for reuse, rather than to decide which specific project to implement today. This is due to the current uncertainty in cost, demand, and wastewater flow projections. However, the Model illustrates which issues are most important in the analysis.

Full Basin Optimization

The results of the Full Basin Model show that, of the 310,000 ac-ft of wastewater generated, 106,860 ac-ft are reused in seven Upper Basin projects, and 203,180 ac-ft are discharged to the river. The value of wastewater to the Lower Basin is great enough to draw the maximum of 200,000 ac-ft down the river after net losses of 3,180 ac-ft. River flow requirements and TDS quality standards are met easily. Flow below Prado Dam is 200,000 ac-ft, at 605 TDS.

Upper Basin Optimization

Using the Upper Basin Model, when the value of reclaimed water to the Lower Basin was omitted, many more Upper Basin reuse projects were selected than with the Full Basin Model. In the initial optimization for the Upper Basin, 154,810 ac-ft of wastewater are discharged to the River, resulting in about 151,600 ac-ft available to the Lower Basin. Wastewater reused in the Upper Basin amounts to 155,240 ac-ft. Flow below Prado Dam is 151,600 ac-ft, at 630 TDS.

Comparison of Full Basin and Upper Basin Optimizations

All of the reuse projects chosen in the Full Basin Model were also chosen in the Upper Basin Model. The 12 additional projects chosen in the Upper Basin Model show a net savings when evaluated by themselves. However, based on initial cost estimates, it appears that the water could be used more beneficially by the Lower Basin. At the baseline costs in this initial Model, results suggest that the Lower Basin could benefit by supporting Upper Basin projects that would maintain discharge to the River.

Sensitivity Analyses

The initial Model results were strongly influenced by the assumed values of certain key parameters. Sensitivity analysis can be used to assess how changes in the key parameters will affect the Model results. Any of the parameter estimates used in the Model could be varied, and the choice of which ones to vary was based on two criteria: the degree of uncertainty in the estimated value, and judgment as to how important the parameter is to the solution. Sensitivity analyses on four key parameters were evaluated.

Effect of Reducing Imported Water Supplies

The Model was used to assess how a shortage of imported water would affect wastewater reuse in the Upper Basin. The restriction was applied uniformly to all agencies (including those in the Lower Basin). Model results indicated that some areas may choose a combination of deficits and increased reuse as a response to restricted imported supply. However, this result was largely determined by the assumed cost of shortage relative to the cost of reuse and by the limited reuse opportunities in some areas. Figure 1 shows the effect on Upper Basin water reuse of limiting imported water supply to 50, 75, 90, and 100 percent of full supply. Results are shown for both the Full Basin

Model and the Upper Basin Model. Because the shortage is imposed on all agencies in the Full Basin Model, it is not clear whether the effect would be to increase or decrease reuse. The effect is indeed insignificant for the Full Basin Model. Although the total cost of meeting demands, allowing shortages, and effluent disposal will increase, the amounts and locations of reuse do not change. The Upper Basin Model shows, as expected, a more pronounced increase in reuse as the shortage increases.

Effect of the Lower Basin Demand on Wastewater Reuse

An important lesson in assessing wastewater reuse in the SAWPA service area is that wastewater can be either reused in the Upper Basin, or discharged to the river and reused by the Lower Basin. The Lower Basin's ability to use river flow to recharge the ground-water basin is, therefore, a driving force in the optimal solution to the Full Basin Model. At the assumed baseline demand of 200,000 ac-ft/yr, Upper Basin reuse totaled 106,860 ac-ft. Figure 2 shows the effect of changing the Lower Basin's demand in the Full Basin Model. (By definition, the Lower Basin's demand has no effect on reuse in the Upper Basin Model.) As the Lower Basin's demand drops, reuse in the Upper Basin rises by the same volume. Increasing the Lower Basin's demand results in a rapid decline in the optimum Upper Basin reuse.

Effect of Imported Water Price Increase

A major benefit of wastewater reuse is being able to avoid purchasing water from an alternative supply. In most areas of the basin, the alternative supply is water imported to MWDSC, so avoiding this cost is a benefit of local reuse. An increase in the price of imported water beyond the projected levels causes the avoided supply cost to rise. Figure 3 shows no impact in the Full Basin Model due to price increases, because the Lower Basin's avoided supply cost rises by the same amount as does the Upper Basin agencies' cost. The total cost of meeting demands and of effluent disposal increases, but the distribution of reuse projects remains the same. The Upper Basin Model results show an increase in reuse as the cost of alternative supply increases.

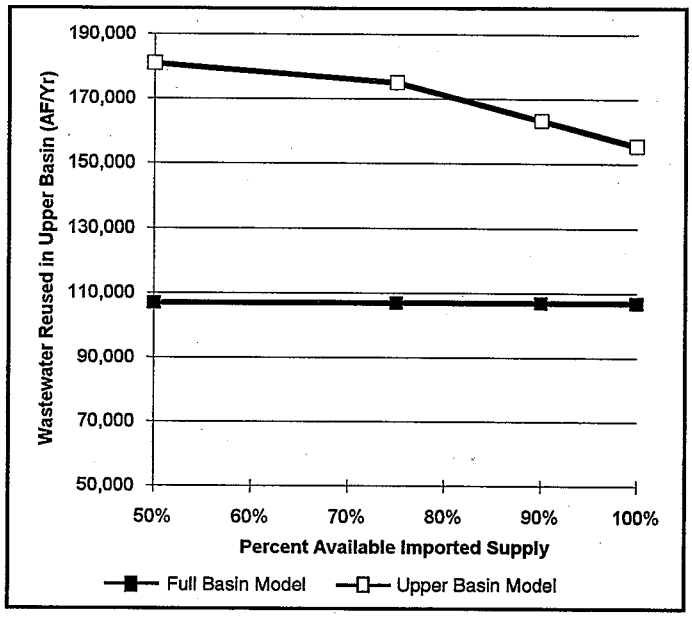

Figure 1. Effect of imported water shortage on wastewater reused in Upper Basin.

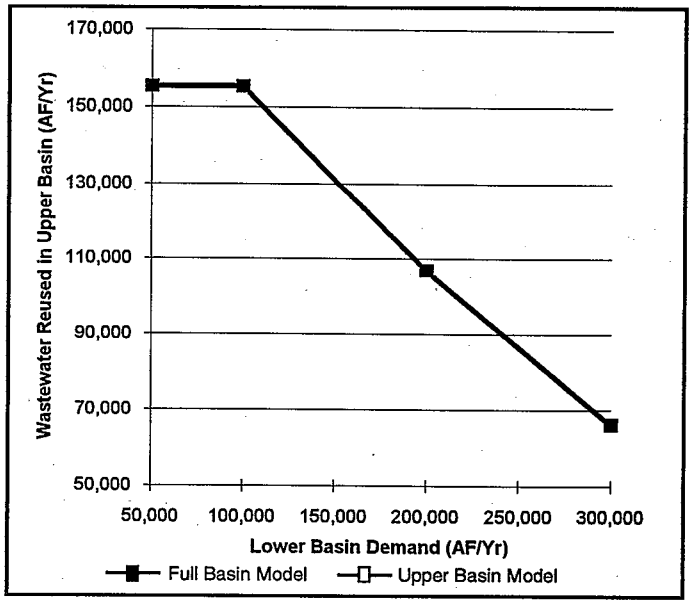

Figure 2. Effect of Lower Basin demand on wasterwater reused in the Upper Basin.

Effect of Higher Wastewater Discharge Cost

The other important benefit of local reuse is the avoided cost of discharging wastewater. The assumed cost of discharge is largely determined by projected requirements for surface water quality. However, future requirements may be different (most likely more stringent). Stricter requirements can be evaluated in the Upper Basin Model

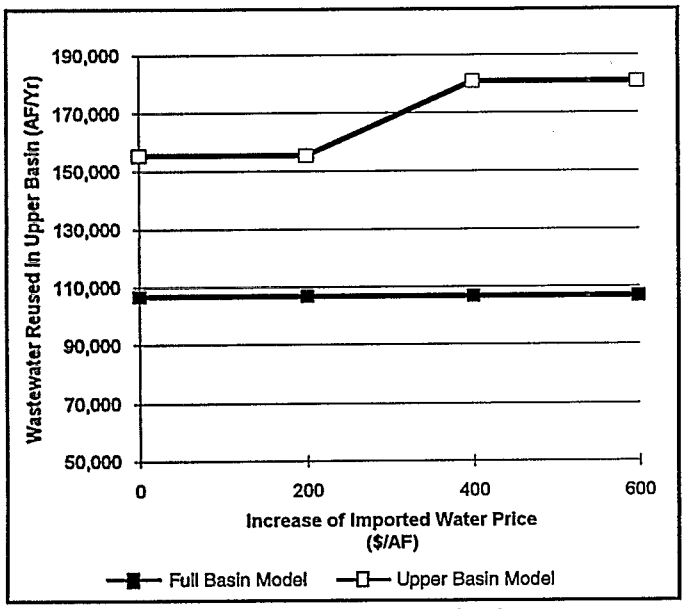

Figure 3. Effect of imported water price increase on wastewater reused in Upper Basin.

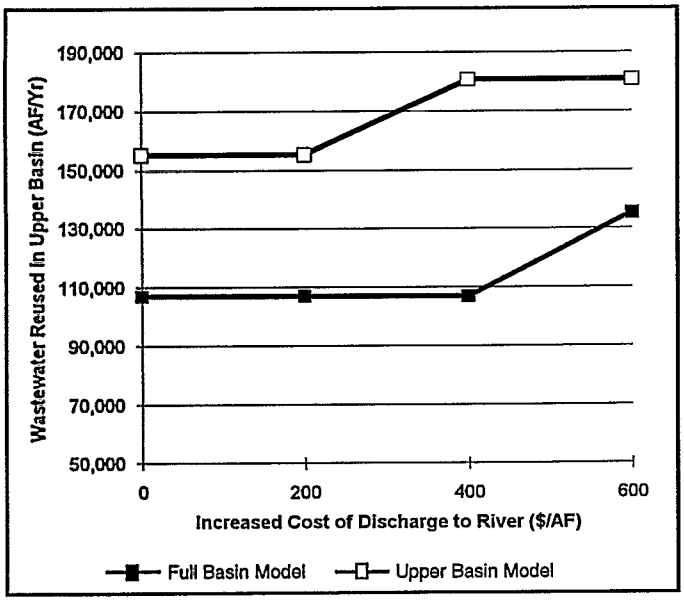

Figure 4. Effect of higher cost to discharge water to river on wastewater reused in Upper Basin.

by increasing the assumed discharge cost. In this Model, a higher discharge cost has the same effect as does an imported water price increase: it increases the benefit of reuse. Increased discharge cost shows the same pattern of response as the imported water price increase, and for the same reason (Figure 4). However, in the Full Basin Model, a higher discharge cost does not fall uniformly on all agencies, because the Lower Basin does not discharge wastewater to the river. Thus, even in the Full Basin Model, an increase in discharge cost will improve the desirability of reuse in the Upper Basin.

Summary and Recommendations

The Model developed for the study underscores many of the local existing intuitive assumptions regarding the relationships between water demands, wastewater disposal, and river flows. However, the Model *quantifies* these relationships and the associated cost impacts of activities of the individual SAWPA member agencies. The initial optimization used available data to provide an enlightening, although somewhat limited, answer to these critical issues. With more refined and consistent engineering data, the Model inputs can be easily changed to more deeply evaluate specific factors (including costs) and their relationships.

A key facet of the optimization Model is that it identifies the most cost-effective combination of projects, minimizing costs to all in the basin. However, the benefits of an optimal solution must be distributed equitably to be an implementable project. A comparison of the Full Basin Model to the Upper Basin Model suggests that incentive payments by the Lower Basin to induce greater discharge from the Upper Basin could be beneficial to all SAWPA member agencies. The payment amount would be negotiated and must be based on more detailed cost estimates.

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Cost Analysis for Nonpoint Source Control Strategies in the Chesapeake Basin

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U.S. Environmental Protection Agency, Chesapeake Bay Program, Annapolis, MD

The nonpoint source pollution (NPS) costs related to implementation of control programs in the Chesapeake Bay are not site-specific. The costs represent the diverse conditions over the entire basin and the limited number of land uses that the model can simulate. The basin covers 64,000 square miles and drains portions of six states and the District of Columbia. Table 1 provides the distribution of 1985 watershed model land uses for the basin.

Table 2 shows the NPS nutrient loads by the various land uses in the basin. Agricultural land uses—crops, pasture, and animal facilities—contribute 58 percent of the total NPS nitrogen and 82 percent of the total NPS phosphorus loads to the Bay. Forest, urban, and water land uses make up the remaining 42 and 18 percent, respectively. (Water land use represents free water surfaces such as rivers, lakes, and streams but not the tidal portions of the Bay itself.)

Estimates of relative load contributions from individual land uses are provided. For example, even though forests comprise 60 percent of the land in the basin, the nitrogen load from forests is only 27 percent of the total NPS nitrogen load.

NPS Cost Analysis

As part of the process to reevaluate the 1988 Basinwide Nutrient Reduction Strategy, the Chesapeake Bay Program Office worked with the states to refine and expand both the watershed and the Bay models. The models simulated load reductions and water quality responses to management scenarios for both point and nonpoint source control activities. One of the scenarios tested was a limit of technology (LOT) for NPS. This is better defined as best available technology (BAT) applied to lands that are sources of NPS.

Using the results from model simulations and NPS control technology cost data developed for the Bay program, it is possible to determine the overall costs of reducing NPS loads within the basin.

Watershed Model Decision Rules for LOT Scenario

Decisions regarding use of the watershed model to simulate a LOT or BAT scenario were made by the Nutrient Reduction Task Force of the NPS Subcommittee. Because the model does not

Table 1. Distribution of land use used in the Chesapeake Basin Watershed Model

Land Use	Total Acreage	% of Total Basin
Cropland[a]	8,237,125	20.00
Pasture	3,740,981	8.96
Forest	24,457,144	60.00
Urban	4,032,669	10.00
Water	526,115	1.00
Animal Waste	12,650	0.04

[a] Includes conventional and conservation tillage and hay land.

Table 2. Nitrogen and phosphorus loadings by land use. 1985 base case loads from Watershed Model.

Land Use	Total Nitrogen	Total Phosphorus
Cropland[a]	107,363,945	9,579,188
Pasture	19,944,389	988,612
Forest	69,154,496	735,042
Urban	32,702,583	2,098,749
Water	5,938,403	189,542
Animal Waste	19,419,035	2,914,660
TOTAL NPS	254,522,852	16,505,793

[a] Includes conventional and conservation tillage and hay land.

simulate all of the NPS best management practices (BMPs), some practices were combined. Reduction values were developed for each grouping used for the scenarios. Ground rules were established for making adjustments to the Watershed Model input deck for the NPS actions of the LOT scenario.

There are two types of reductions in the scenarios: a reduction by conversion of one land use to another and a percentage reduction due to actual BMP implementation.

Application of one or both of these reductions is dependent on the NPS BMP type and the model structure. Some of the acreage categories receive both types of reductions, while others only receive one type. An explanation of the associated reductions is included with each category.

- *Conventional tillage cropland.* All conventional tillage acres are converted to conservation tillage acres.
- *Highly erodible land (HEL).* The 1991 U.S. Department of Agriculture Soil Conservation Service (SCS) data base identifies the area of highly erodible land in each county. It was used to determine the HEL land areas greater than 25 percent of the total crop acres in the county. In these areas, no more than 25 percent of the county cropland would be counted as HEL acres. Total HEL acres in each model segment were aggregated up from the county level data. Highly erodible acres are removed proportionally from conservation tillage and hay land acres and placed in pasture land use.
- *Structural BMPs.* Structural BMPs include any physical or constructed practice implemented on cropland, such as vegetated filter strips or waterways. This category does not include the animal waste category. Structural BMPs were applied only to conservation tillage land use. The acres treated by structural BMPs are assumed to receive a 4 percent nitrogen (N), 8 percent phosphorus (P), and 8 percent biological oxygen demand (BOD) reduction. These reductions are realized from installing a "farm plan" on conservation tillage and hay land acres. "Farm plan" is defined as the additional structural BMPs necessary, when added to conservation tillage, that would bring the land into compliance with "T" or the 1990 farm bill requirements. (The parameter "T" represents the soil tolerance level for erosion, i.e., the maximum soil loss per acre of cropland that can be incurred without reducing the productivity of the soil for the designated crop.)
- *Nutrient management.* Nutrient management was applied to all conservation tillage and some hay land acres. These acres received the nutrient reductions calculated for each model segment from nutrient reduction data furnished by each state.
- *Animal waste.* Reductions in manure runoff loadings are assumed to be controlled to the level of 75 percent. Seventy-five percent of the total manure acres in each model segment are converted to pasture acres. The remaining 25 percent of the manure acres represent residual animal waste runoff loads of current animal populations after the full implementation of controls.
- *Pasture.* Acres treated by grazing land stabilization systems, stream protection systems, or spring development are assumed to be applied to pasture land and receive a 4 percent N, 8 percent P, and 8 per-cent BOD reduction. This reduction applied to all pasture land.
- *Urban.* Urban loads are reduced in all pervious and impervious urban land uses. Urban acres receive a 20 percent P, 20 percent N, and 25 percent BOD reduction based on estimated reductions for urban BMPs.
- *Forest.* Forest BMPs provided an overall reduction in the forest loads for each state as follows: Pennsylvania NH_4 = 5 percent, PO_4 = 5 percent, and BOD = 5 percent; Maryland NH_4 = 7.5 percent, PO_4 = 7.5 percent, and BOD = 7.5 percent; and Virginia NH_4 = 10 percent, PO_4 = 10 percent, and BOD = 10 percent. (NH_4 = ammonium ion; PO_4 = phosphate ion.)

Cost Analysis of LOT Scenario for Agreement States

The NPS cost analysis is based on the decisions discussed above for the scenario simulating LOT load reductions.

The costs for LOT are determined by assigning BMP costs from Table 2.6 of the draft cost analysis study (Camacho, 1992) to the acres treated in the LOT model simulation for the following practices: HEL-Conservation Reserve Program (CRP), Animal Waste, Urban Cost, Conservation Tillage, Nutrient Management. Per acre costs for Forest, Pasture and Farm Plan were developed during a June 16, 1992 conference call among the states, the Interstate Commission of the Potomac River Basin (ICPRB), and the Chesapeake Bay Program Office (CBPO). The agreed upon cost per acre was applied to the total acres for Farm Plan of $15.00 and for Pasture of $2.50, the cost of treating an acre was adjusted in order to get a cost that could be applied to the total acres in the category. The cost for Forest was obtained from information presented in the *South Journal of Applied Forestry* (Lickwar et al., 1990) and used in the following manner. The cost to install enhanced BMPs was 5.1 percent of the gross value of the harvest. In Virginia the gross value is about $1,000 per acre. Annual harvested acres were estimated to be one percent of the total forest acres.

NPS costs used for this analysis are average costs for the entire basin and do not represent the cost in any one river basin or tributary. These average cost represents a very wide range, and, in some cases, may be misleading when related to a single tract of land.

- *Forest cost.* The total forest acres (20,333,492) were multiplied by 1 percent and $51.00 per acre to get the total cost of $10,370,081. The $51.00 is the cost for implementing enhanced BMPs on harvested land. This is 5.1 percent of the gross value of the harvested timber ($1000 dollars per acre in Virginia).
- *HEL-CRP cost.* The 528,911 HEL acres were multiplied by the sum of two cost figures—the average farm plan cost, based on the average cost per acre of the examples furnished to ICPRB by Pennsylvania, and the cost of permanent vegetative cover on critical areas. The total cost is $68,758,430 ($130 per acre treated). A land rental rate was not factored into this analysis because the land would still be in "production" as pasture land. Therefore once so treated, the HEL acres become part of the pasture acreage.
- *Animal waste cost.* The model simulates a 75 percent reduction by applying BMPs to all manure acres. This cost is applied to the total manure acres (12,650) used in the model scenario. This number was divided by .75 and multiplied by the cost of $8,187 to get the total cost of $84,563,523. Once treated, 75 percent of the acres become part of the pasture acreage.
- *Urban cost.* The urban costs were developed by multiplying the total urban acres (3,215,863) by the cost of large scale urban retrofit BMPs at $200.00 per acre for a total urban BMP cost of $643,172,600.
- *Conservation tillage cost.* The remaining conventional tillage acres (1,909,649) were multiplied by the cost of conservation tillage, $17.43 per acre, to get a total cost of $33,285,175.
- *Pasture cost.* The total pasture acres (3,606,133, which now include the original pasture acres plus 75 percent of the manure acres and the HEL acres, were multiplied by $2.50 per acre to get a total pasture cost of $9,015,332.
- *Nutrient management cost.* The conservation tillage acres (4,088,508) were multiplied by the cost of nutrient management, $2.40 per acre treated, to get a total cost of $9,812,420.
- *Farm plan.* The load reduction for farm plan is calculated by reducing the nitrogen load from conservation tillage and hay land acres after nutrient management has been applied. The total acres of farm plan (6,590,132) (conservation tillage plus hay land acres) were multiplied by $15 per acre to get a total cost $66,169,082.

Cost Summary for the Basin

Total NPS costs and the pounds of nitrogen removed for each BMP practice or

grouping are shown in Table 3, along with the cost per pound of nitrogen removed. This data provides a comparison of the various BMPs available to control NPS nitrogen. The least costly of these are nutrient management followed by animal waste control. The combination of these two practices removes about 66 percent of the total nitrogen load at about 10 percent of the total cost. The urban category is most costly. with removal of about 11 percent of the total nitrogen load at about 70 percent of the total cost.

Table 3. Cost of implementation of BMPs in the Chesapeake Bay Basin

NPS, "LOT" N Cost Analysis Summary by Management Practice for Agreement States - Total				
Management Practice	**LOT Cost $ X 1000**	**LOT N #N X 1000**	**% of Total**	**Cost/Pound N $/# N Red.**
Urban	$643,172	4,509	10.64%	$142.64
Forest	$10,370	150	0.35%	$69.13
Farm Plan	$66,169	1,462	3.44%	$45.27
Hel	$68,758	2,991	7.05%	$22.99
Pasture	$9,015	910	2.15%	$9.90
Low Till	$33,285	4,476	10.56%	$7.44
Animal Waste	$84,563	11,801	27.84%	$7.17
Nutrient Mgt.	$9,812	16,096	37.97%	$0.61
TOTAL	$925,146	42,395	100.00%	

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Cost-Effective Implementation of Watershed Management Objectives: Purpose and Approach of the Analysis Team of North East Wisconsin Waters for Tomorrow

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Introduction and Background

Before describing why North East Wisconsin Waters for Tomorrow (N.E.W.) and its Analysis Team were formed, it is necessary to give a brief background on water resources problems and management activities in lower Green Bay and the Fox-Wolf River watershed. The Fox and Wolf Rivers drain a watershed of approximately 17,000 square kilometers in northeastern Wisconsin, emptying into lower Green Bay and Lake Michigan (Figure 1). While the drainage area is largely agricultural, it also contains forested land, urban area, and industrial activity. Water resources provided by the basin provide different types of recreation and drinking water for thousands of people, as well as valuable wildlife habitat.

Lower Green Bay has had water quality problems for at least this past century, if not longer (Ashworth, 1986). Over the past few decades, water quality in lower Green Bay has improved greatly, but significant water quality problems remain (Harris, 1992). In 1985, the International Joint Commission (IJC) designated lower Green Bay and a section of the lower Fox River from its mouth to the De Pere Dam as an Area of Concern (AOC). As a result of a 1985 recommendation of the IJC, the United States and Canada committed themselves to developing and implementing Remedial Action Plans (RAPs) to restore beneficial uses in lower Green Bay and the 42 other AOCs identified in the Great Lakes (IJC, 1985).

In 1988, the Wisconsin Department of Natural Resources (WDNR), with support from the U.S. Environmental Protection Agency (EPA) and extensive local involvement, produced a Remedial Action Plan for lower Green Bay (WDNR, 1988). This document identified problems in lower Green Bay and potential remedial actions; it was the first RAP to be completed. In the process of completing the RAP document, many diverse interests were brought together to decide upon a set of goals and objectives for water resources management. In addition, many remedial actions were listed to address the identified problems and ranked as to their perceived importance.

Since its completion, the Green Bay RAP has moved on to the implementation stage. However, there continue to be many obstacles to implementing the plan and achieving desired conditions, as described by Harris (1992). Many remedial actions recommended by the RAP, such as the reduction of nutrient loading, cleanup of contaminated sediments, protection of

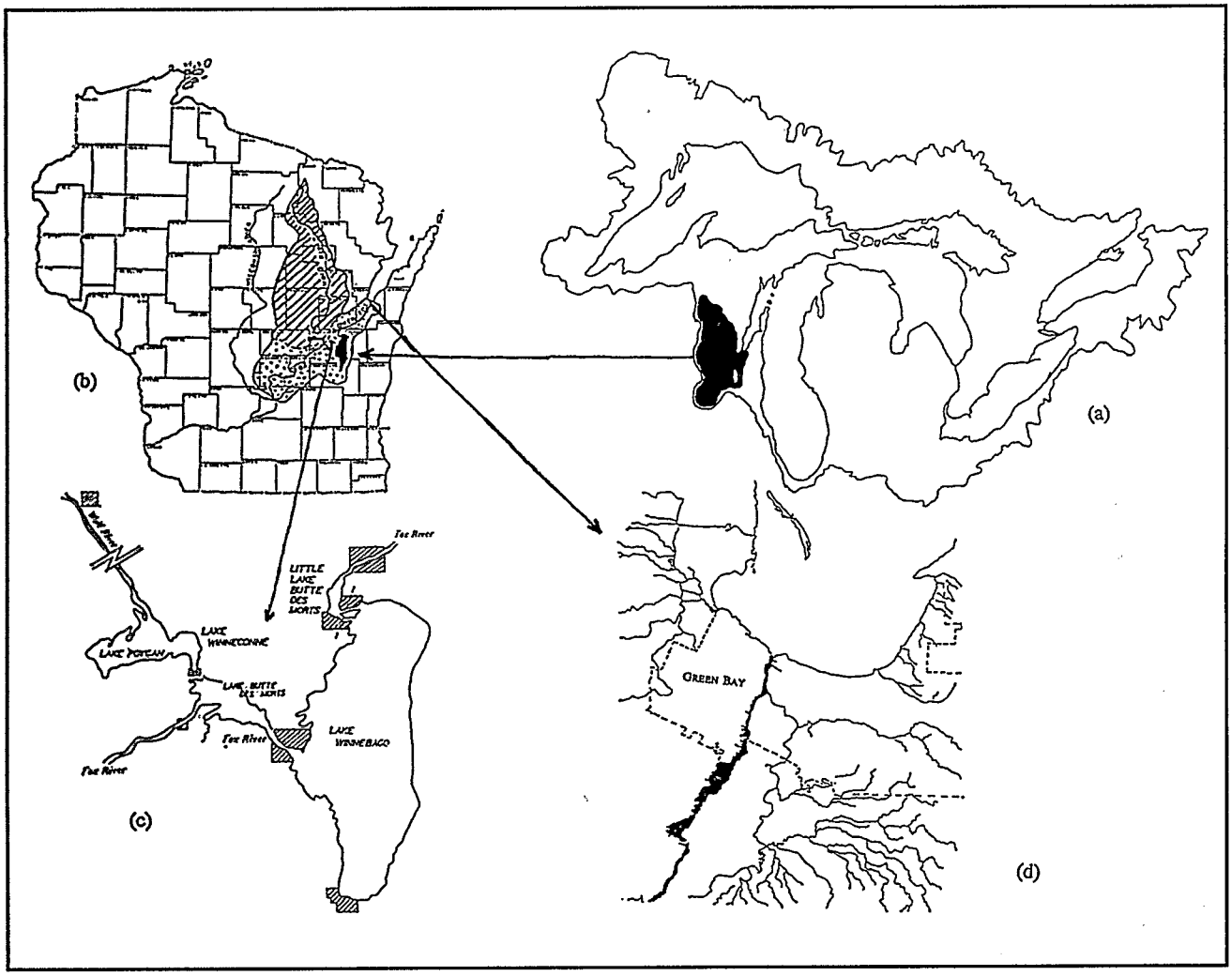

Figure 1. Location of the Fox-Wolf River watershed emptying into lower Green Bay in the Great Lakes (a) and in Wisconsin (b), and the location of the Winnebago Pool Lakes (c) and lower Green Bay (d).

habitat, and enhancement of recreation, require significant effort and funds.

Water quality in lower Green Bay is greatly influenced by activities throughout the Fox-Wolf watershed. At the same time, the RAP process in lower Green Bay is but one of the many water resources management efforts in the Fox-Wolf watershed. Many other management efforts are being undertaken by a variety of agencies in many political jurisdictions at the state, federal, and local levels.

Rationale for N.E.W. Waters for Tomorrow

Concern for the high cost of implementing the Green Bay Remedial Action Plan led a handful of Green Bay area citizens to initiate N.E.W. Waters for Tomorrow. These individuals felt that the RAP's objectives were sound, but they recognized that the cost of achieving them might be prohibitively high. Also, they realized that resources are scarce, and that there are other worthy social concerns besides water quality in need of scarce funds. They also believed that state and federal funds for water quality projects were drying up, and that funds to implement the RAP would largely come from local sources. Therefore, the founders were concerned that dollars for water resources management be spent where they could have the greatest effect.

Given these concerns, founders of N.E.W. Waters for Tomorrow felt that

information about the ecological and economic impacts of water resources management decisions could be better presented in terms that will enable decision makers to better allocate scarce funds. While the RAP document presented many recommendations and general cost estimates, it did not explicitly use cost-effectiveness as a criterion for ranking management actions. N.E.W. Waters for Tomorrow was formed to influence policy so as to ensure that water resources objectives were attained at the least cost to society.

The Analysis Team

The founders of N.E.W. Waters for Tomorrow decided that in order to determine the least-cost way to achieve desired water resources objectives, an independent cost-effectiveness analysis was required. Cost-effectiveness analysis differs from benefit-cost analysis in that its purpose is to determine the least cost strategy to achieve specified objectives. Benefit-cost analysis seeks to determine the strategy which maximizes net benefits. Therefore, with cost-effectiveness analysis, there is no need to quantify benefits nor to determine the appropriate level of environmental quality. The founders of N.E.W. Waters for Tomorrow realized that cost-effectiveness analysis was more appropriate because management objectives were already determined by the Remedial Action Plan.

Funds were raised from a variety of local sources to hire an interdisciplinary Analysis Team to generate information for resource allocation decisions on water resources management in lower Green Bay and the Fox-Wolf watershed. Specifically, the Analysis Team was hired to accomplish the following three objectives over a 1- to 3-year period:

1. To identify, where possible, the most cost-effective management strategy (including physical measures, implementation incentives, institutional arrangements, and financing packages) to meet desired water quality, habitat, and recreational objectives in the watershed.
2. To develop an analytical framework to use in continuing analysis and planning for water resources management in the Fox-Wolf watershed and lower Green Bay.
3. To identify the nature and importance of uncertainties related to cost-effective water resources management in the watershed.

The Analysis Team Approach

An important aspect of the approach is that it is directed at the entire watershed. However, this discussion will first describe how a cost-effective management strategy for the lower Green Bay's water resources management objectives will be determined. Later, it will discuss how the analysis framework incorporates the remainder of the watershed.

The Analysis Team has decided to analyze three dimensions of water resources objectives:

1. Ambient water and sediment quality (problems associated with phosphorus, suspended solids, and toxic polychlorinated biphenyl (PCB) contamination
2. Habitat requirements.
3. Water-based recreation.

These dimensions reflect the most important management concerns in the watershed at the present time, but are not all inclusive. However, the framework could easily be expanded to address other problems.

In order to determine the least-cost management strategy to attain desired water resource objectives, it is necessary to define explicitly and quantitatively what the objectives are. The lower Green Bay RAP contains a list of goals and objectives, many of which are specific. However, some of these objectives are general and/or qualitative. Before it is possible to estimate costs and determine a least cost strategy, the qualitative objectives must be quantified.

After explicitly defining the set of desired objectives, it is then necessary to quantify what is physically necessary to achieve the objectives. For instance, to determine how to most cost-effectively achieve the water clarity objective of 1.3-m Secchi disk depth (a relative measure of water clarity) in lower Green Bay, it is necessary to estimate the different sources of the water clarity problems (i.e., phosphorus (P) loads that promote algal growth, total suspended solids (TSS) loads); the relative contribution of P and TSS from different sources; and by how much loads of P and TSS entering lower Green Bay need

to be reduced to meet the desired water clarity objective. Some of this analysis has been or is being carried out by the lower Green Bay RAP process. However, some additional information must be gathered by the Analysis Team.

The Analysis Team felt it appropriate to make as certain as possible that a selected management strategy would accomplish the objectives in the future as well as at present. The Analysis Team will therefore project what pollutant loads will be circa (ca.) 2010 without any additional funds spent on water resources management beyond the level spent today. Because of the uncertainty in predicting the future, the Analysis Team will make four projections, or *alternative futures*, of conditions ca. 2010. The four projections result from the combination of two different sets of economic and demographic projections, high and low growth, and two different sets of assumptions about behavior, factor prices, and technological changes, or *scenarios*, which affect discharge coefficients. Of the two scenarios, one will yield discharge coefficients based on current trends, while the other will yield lower discharge coefficients based on more optimistic assumptions about behavior and technology. Because of the different assumptions inherent in each scenario, each alternative future projects different pollutant loads, impacts on habitat, and recreation needs.

The resulting water resources conditions associated with each alternative future will be estimated and compared to the desired objectives. If the water resources objectives are not going to be met for the conditions in an alternative future, then a management strategy is necessary to achieve the objectives. Then the main task for the Analysis Team is to determine the least-cost management strategy for that alternative future and to compare the costs of management options with their effectiveness at meeting the objectives. The basic framework is diagramed in Figure 2; it is heavily influenced by the work of Bower (1991).

Alternative Levels of Quality

Attaining some of the goals and objectives for the desired future state may require significant financial investments. It would be useful to approximate the cost of alternative levels of water resources quality and the least cost management strategy that achieves these levels. Such information may reveal what society would get for different levels of investment. Approximating the costs of different levels of quality in no way advocates what should be done; that is left to the social, political, and legal process. However, it provides information about the ramifications of choosing a particular course of action.

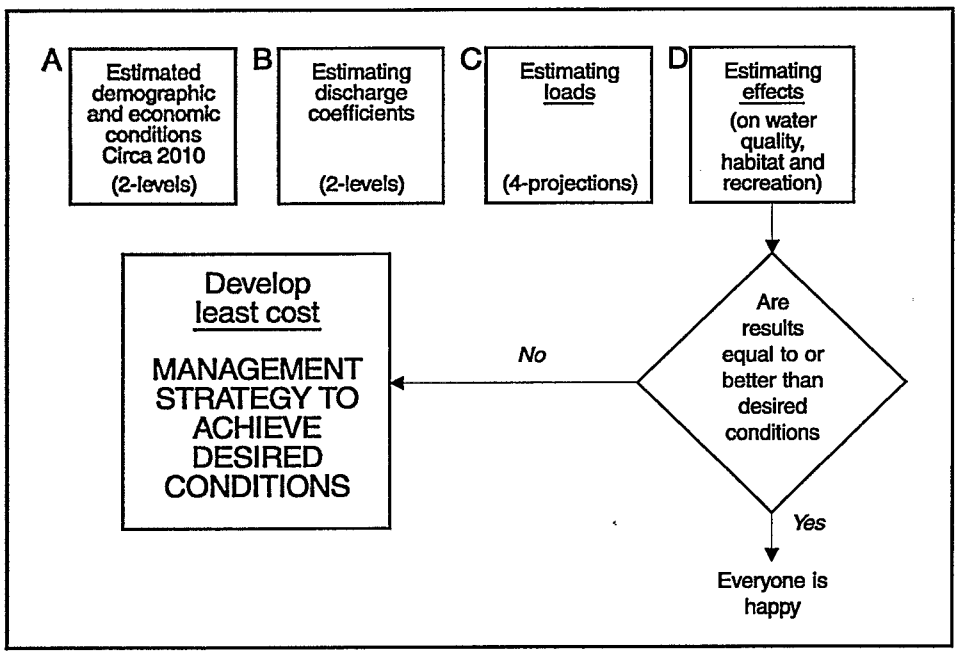

Figure 2. Flowchart of basic elements of the analytic framework.

Approximating the costs of alternative levels of water resources quality is difficult, because quality levels are hard to define. The Green Bay RAP has already produced a list of desired objectives, which represents one level of quality. The Team proposes to determine the least cost management strategy for only two other levels of quality. A second level of water resources quality is that resulting from a situation where there are no additional management actions ca. 2010, in addition to those in existence and being enforced ca. 1990. A third level of water

resources quality represents present (ca. 1990) water resources conditions.

Example: Phosphorus Reduction

The analysis approach can be illustrated by an example. One of the desired objectives for lower Green Bay is to reduce phosphorus concentrations. Phosphorus inputs to lower Green Bay come from a variety of point and nonpoint sources throughout the watershed. Sources include runoff from agricultural lands, urban storm runoff, and point sources. To determine the cost-effective management strategy to reduce phosphorus, it is necessary to estimate what reduction in phosphorus load is required to meet the desired concentration level. The problem then becomes how to ensure that the reduction in total phosphorus load, from the various sources under projected future conditions, is at least equal to this level.

In the future, phosphorus loads will depend upon the level of economic and demographic activity. Phosphorus loads will also depend upon what happens regarding technology, individual behavior, and factor prices. Thus, even before a management strategy is applied, the four alternative futures will have different phosphorus loads associated with them. Therefore, for each alternative future a different amount of phosphorus load reduction is likely to be required, both to meet the desired objective as well as to maintain the 1990 phosphorus concentration. For each alternative future, different management options that reduce phosphorus will be analyzed for their total cost and the amount of phosphorus removed. Thus, the cost per unit phosphorus reduction can be calculated for each option. Determining the least cost management strategy involves adding measures in order of the lowest cost per unit phosphorus removed until the necessary phosphorus load reduction is attained. Thus, each of the four alternative futures may have a somewhat different set of physical measures directed at phosphorus reduction, with a different price tag.

Watershed Analysis

Because activities throughout the watershed affect lower Green Bay, it is necessary for the analysis to focus on the entire watershed. As described above, the analysis will first examine actions throughout the watershed for their costs and effects on management objectives developed for lower Green Bay. While developing the framework, the Analysis Team soon realized that it may be difficult to implement actions throughout the watershed to benefit lower Green Bay. Individuals upstream of lower Green Bay may be reluctant to participate in a management strategy identified for lower Green Bay when they are unsure of what it will cost them and what they will get out of participating. Therefore, it was deemed important to determine the most cost-effective management strategy for management objectives in other areas of the watershed, in addition to lower Green Bay.

The approach the analysis will take in order to incorporate the entire watershed is as follows. First, the Analysis Team will identify the most cost-effective management strategy to reach the desired objectives for lower Green Bay. While this management strategy is likely to require actions upstream from lower Green Bay, it will also improve water resources conditions upstream. The analytical framework then must be applied to the objectives for other parts of the watershed, called sub-areas of analysis, where management objectives can be identified and quantified. For these sub-areas, the following question will be posed: If the cost-effective management strategy identified for lower Green Bay is adopted, will the water resource objectives in that sub-area be met? If not, then the Analysis Team will determine the least-cost set of additional measures needed to meet the objectives for the sub-area.

Given limited resources, the Analysis Team has chosen to initially focus on only one other sub-area of analysis besides lower Green Bay—the Winnebago Pool lakes (Figure 1)—for the following reasons:

1. Management objectives have been specified for Lake Winnebago, as they have for lower Green Bay.
2. The Analysis Team feels that the importance of Lake Winnebago to the quality of the entire watershed has not been adequately considered in the past.
3. Many people live around Lake Winnebago, and depend on it for recreation and drinking water.

In sum, results of the analysis should assist and promote watershed management.

Managing Uncertainty

There is uncertainty associated with many aspects of the approach. Uncertainty about economic, demographic, social, and technological changes in the future is captured to a large degree by having four alternative futures. There will be uncertainty in much of the background information, such as determining the sources of phosphorous and other pollutants. Also, there is much environmental uncertainty. It will therefore be necessary to report results in ways that reflect the uncertainty involved, such as by bounding estimates or performing sensitivity analyses. It is important to avoid the mistake of oversimplifying a complex system. Given the uncertainty, the Analysis Team will only be able to roughly determine the most cost-effective management strategy. In so doing, however, it will assess the importance of uncertainty on cost-effectiveness. This is useful information for it will help guide policy and establish priorities for further research.

Summary—Relevance to Other Watersheds

The purpose of the Analysis Team is to generate information to enable management objectives to be achieved at the least cost to society. Even though initial results will be rough, cost-effectiveness has not been a major criterion of previous policy decisions and programs for improving environmental quality in lower Green Bay, nor the Fox-Wolf watershed. Therefore, the results of the analysis may be very valuable, perhaps enabling millions of dollars of public funds to be saved. For instance, the analysis should indicate whether the marginal dollar for phosphorus reduction would be better directed at rural nonpoint source pollution, urban storm runoff, or point source improvements. Furthermore, it will indicate which actions are more likely to meet management objectives under future conditions.

N.E.W. Waters for Tomorrow and efforts of the Analysis Team are extremely relevant to other watersheds. The experience over one year will lay down the framework for incorporating cost-effectiveness in resource management decisions in a watershed. This approach to water resources management, the principle of cost-effectiveness applied at the watershed level, should be widely applicable. Concern for costs is likely to become an increasingly important consideration in implementing management plans, as traditional sources of funding dry up. There will be the need for objective information to help determine where scarce funds should best be spent. Therefore, while the framework was developed for one particular watershed, it may be viewed as a prototype for other watersheds in the future.

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South Platte Basin: Application of the Total Maximum Daily Load Approach

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In the 1972 Clean Water Act, Congress included a provision in section 303 that called upon states to develop and implement water quality standards for surface waters. Included in this part of the act is a provision found in §303(d) that requires states to implement their standards through the development of total maximum daily loads (TMDLs). Although this requirement has been in existence for 20 years, most of the effort in implementing TMDLs has focused on point source discharge requirements. As water quality planning takes on a wider perspective, looking at all activities within a watershed, TMDLs have become a valuable tool in translating water quality standards to a combination of point and nonpoint source controls needed to achieve in-stream goals.

The purpose of this paper is to provide a brief introduction to what TMDLs are and why they are important in the course of watershed management. In addition, it will provide a look at the expanding use of the TMDL concept in the South Platte watershed in the Denver metropolitan area. Water quality-based management in the South Platte watershed is not new, but it has recently developed to include the use of untraditional and innovative approaches to address problems in their full ecological context.

What Is a TMDL?

The Clean Water Act provides for a two-tiered approach in water quality controls. The most basic controls are those referred to as "technology-based controls." These serve as a minimum baseline of treatment expected of point source dischargers, independent of the type and classification of waterbody receiving the discharge. For example, the water quality requirements for a steel mill in Gary, IN, are based on the same baseline requirements as for a steel mill in Provo, UT. Where the application of technology-based controls is not sufficient to achieve in-stream water quality standards, then additional controls are needed. These additional "water quality-based controls" include controls on point and nonpoint sources of pollution. Point source controls are regulatory in nature whereas nonpoint source controls are generally nonregulatory. The concept of water quality-based controls comes from section 303(d) of the Clean Water Act—the section that introduces the TMDL process. This paper will focus on the relationship between water quality-based controls and TMDLs.

For purposes of this presentation, the term "water quality standard" will include all components of state standards. Use classifications, numeric standards, narrative standards, and antidegradation provisions are all a part of state standards. The TMDL process has a role in the implementation of all of these components.

The fundamental challenge in water quality management is to select the appropriate level and combination of controls to achieve and maintain the goals established by a state through its standards program. The process is not as straightforward as it may appear. Congress recognized this and established a deliberate step between water

quality standards and water quality controls. This crucial link between standards and controls is the TMDL process.

The statutory requirements placed on a state to develop TMDLs follow closely in many respects with the requirements to establish water quality standards. The U.S. Environmental Protection Agency (EPA) has a review and approval responsibility for both standards and TMDLs. If a state fails to establish a TMDL where needed or if EPA disapproves a state TMDL, EPA has a nondiscretionary duty to establish the TMDL (Scott v. City of Hammond, 1984) (Alaska Center for the Environment v. Reilly, 1991).

The Clean Water Act requires the establishment of TMDLs as a primary mechanism to implement water quality standards, taking into consideration seasonal variation and a margin of safety. Congress directed states to first focus on those waters where water quality-based controls are needed to achieve or maintain water quality standards.

A TMDL for a waterbody is a quantification of assimilative capacity of a receiving water. The TMDL takes into account all sources of the particular pollutant of concern as well as dedicating a margin of safety to account for uncertainties. This concept of TMDLs can be portrayed in a simple equation that identifies the cumulative load from point sources as the *wasteload allocation* (WLA) and the nonpoint source plus background loads as the *load allocation* (LA). The margin of safety can be either a distinct reserve load or it can be integrated into the WLA or LA through conservative assumptions.

$$TMDL = \Sigma WLAs + \Sigma LAs + (\text{Margin of Safety})$$

where, TMDL = total maximum daily load
WLA = wasteload allocation (point sources)
LA = load allocations (nonpoint sources plus background)

EPA's regulation on the development and implementation of TMDLs provides for flexibility in how TMDLs are described (USEPA, 1992). There are numeric in-stream standards or criteria that lend themselves to the calculation of mass loadings and concentrations. For example, an industrial treatment plant may be limited to a certain amount of pounds per day of copper to maintain a certain ambient standard, given in micrograms/liter (mg/l). Likewise, a number of sources could be allocated a certain amount of pounds of phosphorus per year to maintain a target annual loading requirement into a lake. Other parameters of concern, such as sediment from nonpoint sources, may not lend themselves to a pounds per day limitation, but may best be described in a TMDL as a percentage reduction from current loadings.

Through the years, EPA has published documents on the technical aspects of developing TMDLs. More recently, EPA published a guidance document that is intended to explain the programmatic aspects of TMDLs, discussing the roles of the state and EPA in the development of TMDLs (USEPA, 1991). This document also provides a description of how the TMDL process fits with other EPA water quality programs.

The Clean Water Act defines the roles of the states and EPA in developing TMDLs. Most recently, EPA revised its regulations on TMDLs to further delineate the state submittal process. In the revisions to the rule, EPA has required each state to submit the section 303(d) list of TMDL waters every other year, starting in 1992. This submittal coincides with the states' biennial section 305(b) water quality report to Congress. In addition, each state is to target waters for TMDL development over a 2-year period and submit them to EPA for review and approval.

The TMDL and Watershed Management

The most relevant role the TMDL plays in the watershed management process is to act as a focus of all technical deliberations used as a basis for water quality controls in the watershed. The TMDL process is designed to determine what level and what combination of controls are needed to achieve water quality goals. To best accomplish this, the TMDL process must be holistic in nature, considering all sources of pollution loading within a watershed. In addition, the TMDL process accounts for "nonchemical" factors such as flow, channel morphology, and riparian habitat that, if in a degraded state, can contribute to the nonattainment of water quality standards and in-stream uses. Once the framework for a TMDL has been established, it can be used to evaluate alternative approaches to achieving water quality goals, including the "trading" of

control requirements from one source to another for the purpose of optimizing treatment costs within the watershed.

The TMDL process has aspects that coincide with the spirit and structure of the watershed management process. In particular, the TMDL process calls for the identification, prioritization, and targeting of water quality problems (including existing problems and future problems threatening water quality). Each of these steps in the TMDL process calls for the participation of the stakeholders within the watershed. In addition, the identification of solutions as defined through the TMDL is also subject to public participation (USEPA, 1992).

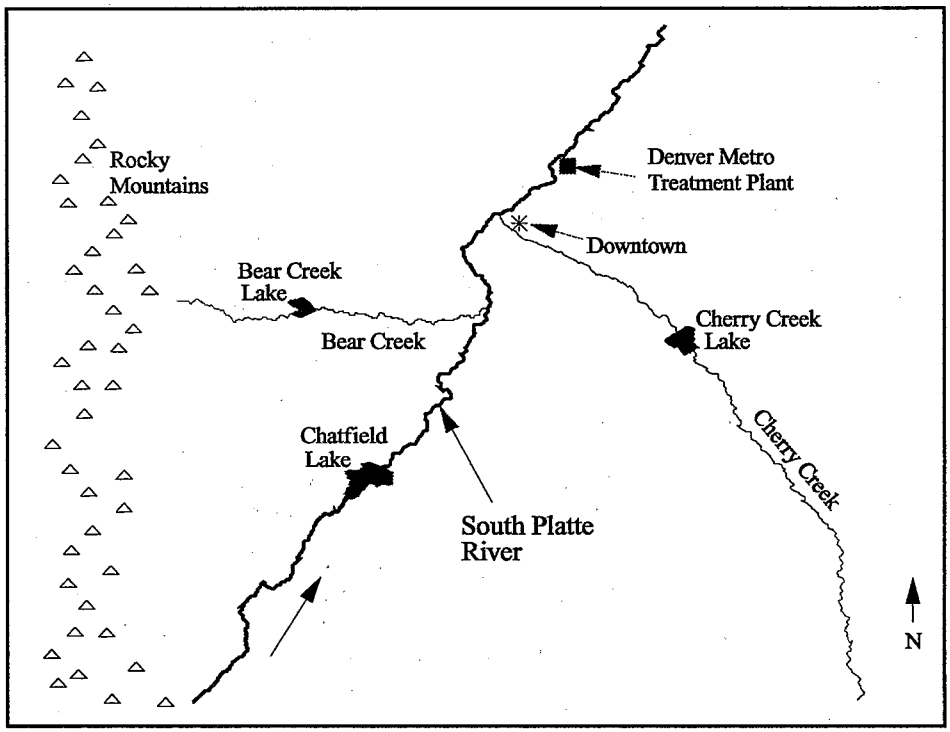

Figure 1. South Platte River through the Denver area.

To best demonstrate some of the principles discussed in the previous paragraphs, a case example using the South Platte River will be presented that exemplifies certain aspects of the TMDL process.

The South Platte River TMDL Process

The South Platte River begins in the Rocky Mountains of Colorado, flowing quickly through the foothills to the plains where metropolitan Denver is located (Figure 1). The focus of attention in this paper will be on the portion of the South Platte as it flows through the urbanized area of Denver.

There exists a history of TMDL development in the South Platte basin. For most of the watersheds above the reservoirs, phosphorus TMDLs have been established by the Colorado Water Quality Control Commission for the purpose of controlling excessive eutrophication. TMDLs have been developed for conventional pollutants and toxics throughout the basin on a less formal basis.

In years past, the portion of the South Platte River with severe water quality problems was the reach below the central urban area of Denver that received storm water runoff as well as effluent from many point source dischargers, the biggest being the Metro Wastewater Reclamation District municipal treatment plant (Figure 2). Low flow conditions are caused in large part to the diversion of the River at the Burlington Canal, immediately upstream from the Metro facility. At low flow, the River is comprised almost entirely of effluent from the facility.

The historic water quality problems included ammonia toxicity, chlorine toxicity, high concentrations of metals, and low dissolved oxygen. The extent of the problem in the mid-1980s was revealed, in part, by biological testing of the river water that demonstrated significant toxicity for over 25 miles downstream of the Metro discharge (Figure 3).

Traditional approaches to developing TMDLs were limited to looking at the immediate point of discharge from the Metro treatment facility. Background loadings at low flow became part of the equation used to develop end-of-pipe limits needed to achieve standards. It appears that for parameters such as chlorine and most metals this approach was adequate to attain water quality standards throughout the river reach.

For other water quality concerns such as ammonia toxicity and low dis-

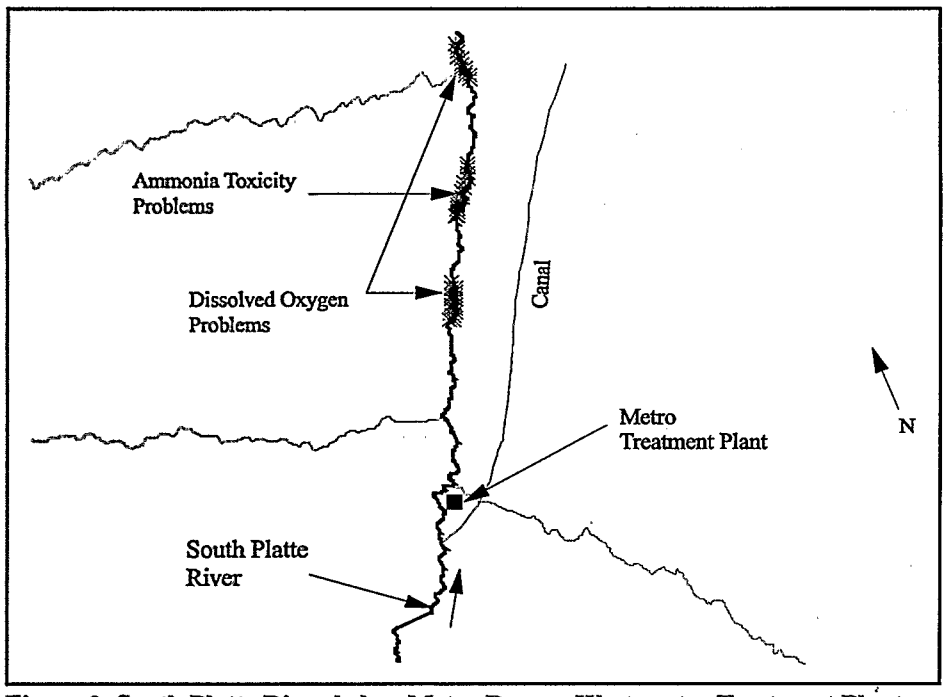

Figure 2. South Platte River below Metro Denver Wastewater Treatment Plant.

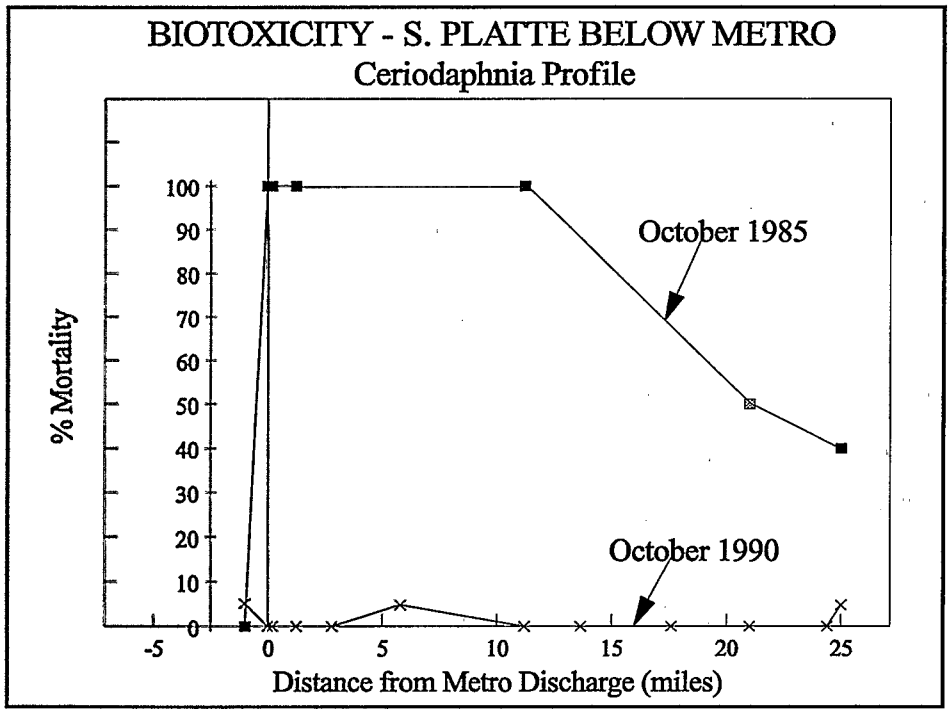

Figure 3. Toxicity profile downstream from Metro Wastewater Treatment Plant.

solved oxygen, the TMDLs could only be developed in a logical manner by analyzing the watershed as a whole, and not focusing only on the point of discharge. This approach is consistent with the premise that a watershed perspective is needed to develop a comprehensive TMDL.

In the course of expanding the analysis in a geographic sense, additional factors needed to be accounted for. The quality and quantity of ground water inflow, the extent of irrigation withdrawals, and the effects of other point source dischargers and tributaries needed to be considered. Again, this is consistent with the premise that all sources need to be considered when developing a TMDL.

After extensive upgrades at the Metro facility, the ammonia toxicity problem has been solved for all reaches of the river. A significant remaining problem for the River includes low dissolved oxygen concentrations at several locations downstream from the Metro facility.

In the course of determining the TMDL to address this problem, the Metro Wastewater Reclamation District has funded studies with the direction and assistance of the U.S. Geological Survey, EPA, and the state to evaluate in a holistic manner the exact causes and possible solutions to this water quality problem. The studies are addressing issues such as:

- *Ambient water quality monitoring.* Biweekly water quality monitoring of the mainstem and major tributaries is being performed to determine trends daily variability in water quality.
- *Fish and macroinvertebrate studies.* Extensive bioassessments of the South Platte are being performed to act as an indicator of biological health of the River. Such information provides information that can be

used to judge success after application of controls prompted by the TMDL.

- *Habitat studies.* Analysis and mapping of stream habitats are being performed to determine areas of degraded habitat that may be candidate areas for restoration and explain more precisely the role of degraded habitat in impairment of the aquatic use. In conjunction with this, an analysis of the avian use of the River is being performed since literally thousands of birds use the reach below Metro's discharge.
- *Ground water interaction with surface waters.* TMDLs need to have a comprehensive analysis of loadings to be most useful. It has been shown in the South Platte as well as in other western streams (Valett et al., 1990) that ground water inflow is a significant issue from both a quality and quantity perspective.
- *Benthic layer studies.* In many of the traditional TMDL studies related to dissolved oxygen, benthic metabolism has often been ignored or otherwise not well documented. In the recent literature, the importance of addressing such an issue is essential (Rutherford et al., 1991a, b; Zagorc-Konca et al., 1991).
- *Dissolved oxygen criteria studies.* The actual "target" water quality standard needed for the TMDL is being re-evaluated by performing site-specific criteria studies. Very few, if any, studies have been performed on the warm-water species of the South Platte. In addition, few studies have been performed using a 24-hour pattern of dissolved oxygen cycling, indicative of natural conditions. The Metro study will be considering these factors in addition to using a combination of field and lab data to determine a recommended dissolved oxygen criterion.
- *Physical modeling of stream morphology.* An actual scale model of the South Platte River has been built to evaluate what changes, if any, the in-stream shape would have on increasing the ambient dissolved oxygen. In particular, certain reaches of the South Platte have been mined for gravel or otherwise reshaped, leaving reaches of deep, slow-moving pools that are areas of low dissolved oxygen. It is proposed that returning these reaches to a more natural habitat type will solve some of the problem associated with the low dissolved oxygen.
- *Mathematical modeling of water quality.* All factors that influence dissolved oxygen will be integrated into a water quality model that will be used to determine the TMDL for achieving the dissolved oxygen target. This model spatially covers the full watershed as well as including chemical, biological, and physical factors. Surface water characteristics, ground-water interaction, benthic layer processes, changes to the stream habitat, loadings from all point and nonpoint sources as well as tributaries and irrigation withdrawals and return flows are considered within the context of the model.

The Metro District is in the process of evaluating a series of alternatives to solve the dissolved oxygen problem. Each alternative is made up of an assemblage of activities that, when applied together, are designed to meet the water quality goals. Of particular note is the mixture of alternatives that include both improvements at the wastewater facility as well as physical stream improvements in certain reaches. Included in the evaluation of the alternatives is the public participation component through which comments and concerns of the stakeholders in the watershed will be solicited.

Through these current studies, there has been a great leap forward in evaluating the South Platte River in a broadened ecological view. The updated TMDL will integrate results of the studies into an assemblage of controls needed to meet the dissolved oxygen requirements of the South Platte.

Beyond the dissolved oxygen problems of the South Platte, there is still one major pollutant source that is subject of future studies—storm water discharges. Storm water discharges throughout the Denver area may be having a cumulative impact on the South Platte River that could be preventing full attainment of the aquatic life use. The TMDL process calls for

spatially as well as temporally comprehensive analyses. The direction of TMDL development in the South Platte River, then, is to begin addressing the full hydrologic cycle of the River, including wet weather events. One of the significant steps in this direction is the ambient biological assessment of the river to detect impairments due to storm water dischargers throughout the central urban corridor. The City and County of Denver are currently sponsoring this work to assess the biological health of resident species as well as discover areas of significant impairment due to storm water discharges.

Summary

As a component of watershed management, the TMDL process promotes the broadening of our perspectives to consider:

- The interaction between all pollutant sources (e.g., point, nonpoint, atmospheric, ground-water sources).
- Cumulative impacts through the watershed.
- The chemical, biological, and physical causes of impairment in a watershed.
- The opportunities for innovative solutions such as pollutant trading and habitat restoration.

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Application of a Nonpoint Source TMDL Approach to a Complex Problem of Mining Waste Pollution—South Fork Coeur d'Alene River

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The Coeur d'Alene Basin of northern Idaho is a region of mountain-fed rivers draining to Lake Coeur d'Alene, the source of the Spokane River. The lake provides 33 percent of the recharge to the Rathdrum-Spokane aquifer, a sole drinking water source of Spokane and its suburban areas. The watershed of the lake contains some of the least impacted drainages in Idaho, as well as some which are the most heavily impacted by a long history of development. Many streams of the upper St. Joe River drainage have minor disturbances confined to a few access roads and the impact of an area-wide forest fire in 1910. In contrast, the South Fork Coeur d'Alene River drainage has been the center of mineral extraction, milling, and refinement activities. Trace (heavy) metals contaminate the river and four of its tributaries at levels exceeding chronic freshwater biota criteria. Metals and sediments from the South Fork (Silver Valley) have been washed downstream to contaminated sediments of the lower Coeur d'Alene River and Lake Coeur d'Alene. Measures are being taken by state and federal authorities to contain the metals contaminants in chemical forms unavailable to fish, wildlife, and the population in these downstream waterbodies. The objective of this paper is to discuss the approach of a nonpoint source based Total Maximum Daily Load (TMDL) to control metal sources with a watershed management perspective.

The Coeur d'Alene Mining Districts of northern Idaho have produced silver, lead, and zinc ores over a 100-year history. The extraction and milling of metals ores proceeded for 80 years with minor concern for environmental protection and with very few measures implemented to protect land and water resources from heavy metals contamination. The metals released to the environment include substantial levels of cadmium, lead, and zinc with minor amounts of chromium, copper, mercury, and arsenate.

Mills often discharged spent ore tailings directly to streams. Some efforts were made to mitigate downstream impacts in response to turn of the century law suits, but the remedies implemented often created their own suite of problems. Early tailing impoundments were located directly next to or in the tributary streams to the South Fork. Impoundment dams breached, and the streams of the narrow valleys cut into the tailing piles. Wooden impoundment dams were constructed to cross Canyon Creek and the South Fork in locations of stream gradient breaks to collect tailings discharged upstream. These were breached by a succession of high-water events. The areas, which were already natural stream deposition zones, became broad alluvial flats laced with all forms of jig and flotation tailings rich in heavy metals. Shallow valley aquifers associated with the natural deposition areas became contaminated with heavy metals. Narrow areas of the valley force these aquifers

to discharge back to the river at these locations. The metals load is carried into the surface waters. Tailings dredged from the river and deposited on the land to prevent their further migration downstream continue to yield metals to the water courses.

The Silver Valley contains the 21-square-mile Bunker Hill Superfund Site. The site is the Nation's second largest. The site boundaries were drawn based on the lead levels detected in the blood of children as a result of smelter gas discharges. Only recently has contamination of water been addressed by the remedial planning process. However, the South Fork Coeur d'Alene River exceeds chronic metals criteria for freshwater biota upstream of the Superfund site boundary. Remediation of the Superfund site metal sources will not fully address the uses of the river.

As the issue of restoring the waters of the South Fork and the tributaries was addressed, Idaho and U.S. Environmental Protection Agency (EPA) Region 10 were confronted with the options of using Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) authorities or a Clean Water Act mechanism to achieve the clean-up objectives. The state and federal governments felt a watershed-based approach to metals source reduction was preferable and most feasible. The TMDL requirements of section 303(d) of the Clean Water Act would be used to develop the metals source reduction plan. Since the South Fork had been listed as water quality limited since 1976, the stage was set for the TMDL approach.

Beneficial Uses Recovery Goals

The South Fork Coeur d'Alene River has the designated protected uses of agricultural water supply and secondary contact recreation. In addition, state water quality standards designate cold water biota and primary contact recreation as uses "protected for the future." These designations were made in 1980 when only the most resistant macroinvertebrates could be found in the South Fork and trout were not present below the Canyon Creek confluence and in limited numbers above that point. Recent studies have demonstrated the further recovery of macroinvertebrates in the stream and use by some trout, where pool habitat is available (Hornig, Terpening, and Bogue, 1988; Hartz, in preparation). Improvement in wastewater treatment facilities has lowered bacteria levels into a range supportive of primary contact recreation. Cadmium concentrations continue to exceed drinking water standards during the low-flow period of the year.

Based on a thorough use attainability assessment, the river was determined to be physically capable of the support of cold water biota, primary contact recreation, agricultural water supply, and secondary contact recreation. The analysis indicates that these uses exist in the South Fork and its tributaries, although cold water biota, primary contact recreation, and agricultural water supply are heavily impaired in many of these stream reaches. The TMDL is being designed to fully recover the impaired uses.

TMDL Approach

Water quality monitoring has been completed by the state (IDHW, 1975) and EPA (Hornig, Terpening, and Bogue, 1988). More recently monitoring results developed for the Bunker Hill Superfund Remedial Investigation-Feasibility Study (McCulley, Frick & Gilman, 1991a) and the State Natural Resource Trust Fund (McCulley, Frick & Gilman, 1991b; McCulley, Frick & Gilman, 1992) have become available. From these data a rough metals loading analysis of the South Fork and its tributaries has been completed.

The loading analysis indicates that 3.5 percent of the total metals load (cadmium, lead, and zinc) is attributable to point discharges issued National Permit Discharge Elimination System (NPDES) permits. Abandoned mine adit drainages, which could be permitted under the storm water runoff program, supply another 6.5 percent of the load. The remaining 90 percent of the load is attributable to other nonpoint contributions primarily from abandoned mill tailing deposits and from tailings deposited as part of the stream bed load.

The predominance of nonpoint source load contribution requires application of a nonpoint source TMDL approach. The approach was initially implemented to address nonpoint source sedimentation of the South Fork Salmon River. The TMDL will focus on the reduction of heavy metals and sediment loads throughout the watershed. Load reductions of metals and sediments sufficient to permit fully sup-

ported cold water biota use is the goal. This goal will ensure support of the additional uses of the stream.

Format of a Nonpoint Source TMDL

A nonpoint source TMDL is constructed very differently than a TMDL addressing point discharges. Where point discharges constitute the majority of the load, the maximum load of a pollutant that a stream can safely assimilate without impairment to the beneficial uses is estimated. Margins for error are built into the estimate. The estimated load is then parceled out in a wasteload allocation to the discharging facilities. Since the nonpoint source component is normally small, in practice it is usually either neglected or point dischargers are each allocated a share of the nonpoint source load.

In a case like the South Fork Coeur d'Alene River where the permitted point discharges are 3.5 percent of the load and other identifiable discharges from discrete points are at most another 6.5 percent of the load, the typical approach will not provide satisfactory results. The nonpoint sources themselves must be addressed in a load allocation.

The State of Idaho has not found a method to allocate loads to nonpoint sources or nonpoint source activities. The nonpoint sources are often either a historical legacy or temporal land disturbance caused by economically vital activities; e.g., agriculture, grazing, and timber harvest. The state has found that remediation or restoration projects can be allocated to land owners with areas on their property which supply a steady load of nonpoint source pollutants. The amount of pollutant load reduction expected from a remedial project can be estimated with mathematical models or project effectiveness monitoring. With these estimates of expected load reduction, an allocation of remedial projects expected to lower the pollutant load to a point sufficient to permit support of beneficial uses can be developed.

The nonpoint source approach requires application of a measure of professional judgement. It is inherently a less certain undertaking than a wasteload allocation to point discharges. As a result of the uncertainty, a nonpoint source TMDL contains provisions for water quality monitoring to assess if the projected load reduction expected of an allocation of projects has been achieved and beneficial use monitoring to assess progress towards use attainment and full support of those uses. At some point after full implementation of the projects and a period of monitoring to assess the effectiveness of the measures implemented, a decision point is reached. If uses are recovered the goal is met. If uses are not recovered another allocation of load reduction projects is implemented and the cycle repeated. A nonpoint source TMDL is a repetitive process which homes in on the desired goal of full support of the uses (Figure 1).

Implementation of the provisions of a nonpoint source TMDL is also a challenge. Implementation of allocated projects on federal lands is possible by inclusion of this approach in section 319 management plans. Section 319(h) of the Clean Water Act can be used to require consistency of all federal projects with the allocation. Compliance by private interests requires provisions in the state standards requiring compliance.

South Fork Coeur d'Alene River TMDL

Application of this approach to the South Fork Coeur d'Alene River will provide an example of this approach in use to recover uses impaired by historic mining activities. The load reduction required can be estimated from the results of water qual-

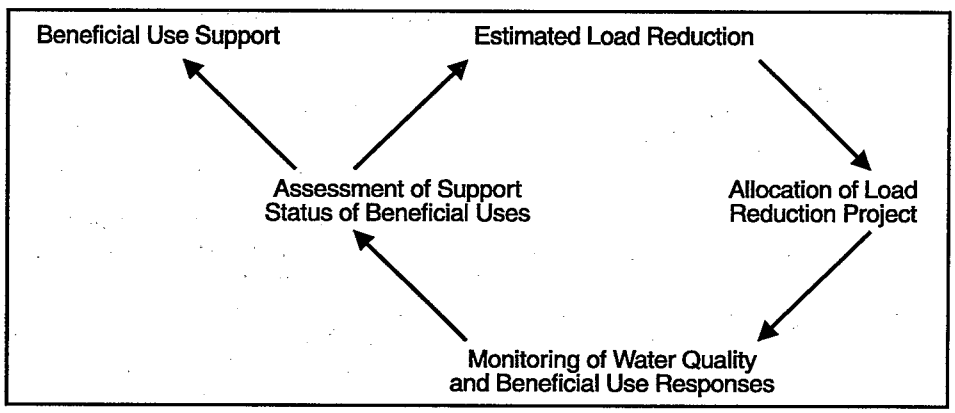

Figure 1. Format of nonpoint source TMDL.

ity monitoring and beneficial use support status monitoring. The metal concentration in locations where cold water biota is fully supported are used to calculate and extrapolate the load reductions required throughout the river system.

The loading analysis which provided estimates of the metals contribution from various sources was completed at sufficient resolution to identify the stream reaches yielding the largest metals loads to the system. The source of these loads could often be identified as a specific mill site or stream deposition area. For example, the loading analysis of the East Fork Ninemile Creek identified four significant loads entering the stream at high flow (Figure 2). At low flow, three of these sources are greatly reduced, indicating these are nonpoint sources. The fourth source is more constant, indicating a more discrete constant source. Field inspection indicates these sources include:

- Interstate Mill Dump.
- Rex Tailing Pond Drainage.
- Success Mill Dump.
- Tailings deposited by erosion and deposition along the lower reach of the East Fork.

An ingredient is not available for a full allocation of load reduction projects in the South Fork. Quantitative data which would allow estimation of the metals load reduction that could be attained from a remediation project are not available. The solution to this problem is an initial allocation of demonstration remedial projects. These projects will be carefully monitored to assess the load reduction achieved. The load reduction data will be used to develop an allocation of load reduction projects which is expected to lower the load to acceptable levels.

Demonstration remedial projects are planned for implementation during the late summer and fall of 1993. Effectiveness monitoring of these projects will be completed after two years. As effectiveness monitoring proceeds, additional beneficial use support status and water quality monitoring will be completed to clearly delineate the load reductions required from the initial project allocation. Implementation of the projects allocated to achieve the desired load reduction should begin in late summer or fall of 1996. Monitoring of water quality and beneficial uses will determine the need for additional allocations. The process will

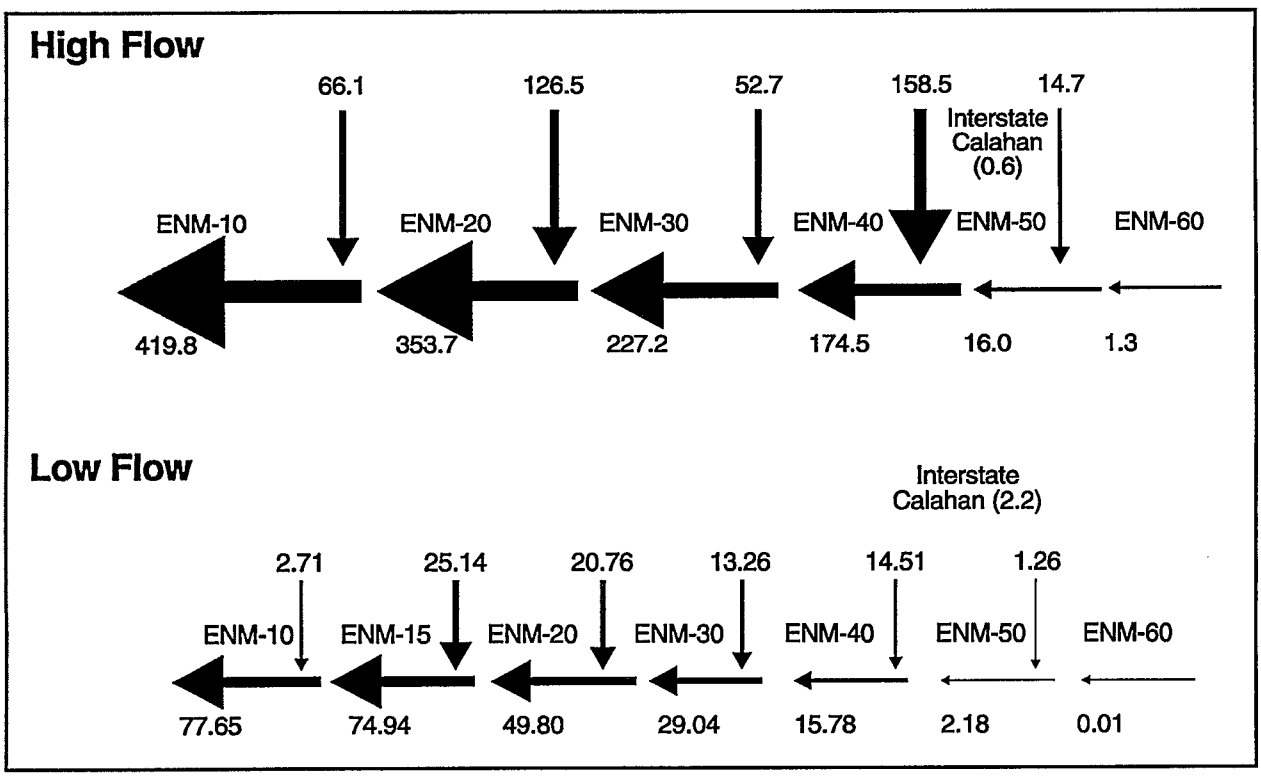

Figure 2. East Fork Nine Mile Creek total metals load (lb/d) at high flow and low flow.

be followed until full support of the attainable uses is achieved.

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A Status Report on Michigan's Comprehensive Water Quality Plan for Sycamore Creek

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Michigan has a provision in its water quality standards for a comprehensive plan to be prepared for a stream that will form the basis for nonpoint source controls to meet the dissolved oxygen (DO) standard. The technical work for the first such plan has been completed for Sycamore Creek and is described in detail elsewhere (Suppnick 1992). This paper presents an overview of this technical work, and a description of ongoing efforts to implement the plan and monitor the results.

Sycamore Creek is a warm water stream that drains 274 square kilometers of gently rolling sometimes flat land in central Michigan. The watershed analysis focuses on the 96 square kilometers upstream of Harper Road (Figure 1). Land use is primarily cash crop agriculture. Although farmers do not typically fall plow, conservation tillage is not yet widely used in the watershed despite the fact that much of the agricultural land is highly erodible. The monthly median flows vary from a low of 125 l/sec (4.4 cfs) in September to a high of 991 l/sec (35 cfs) in March and April.

The City of Mason is near the downstream end of the watershed. There are no major industrial discharges of process wastewater, but the City of Mason discharges wastewater from an advanced wastewater treatment plant (WWTP) with a design flow of 5,680 cubic meters per day (1.5 MGD).

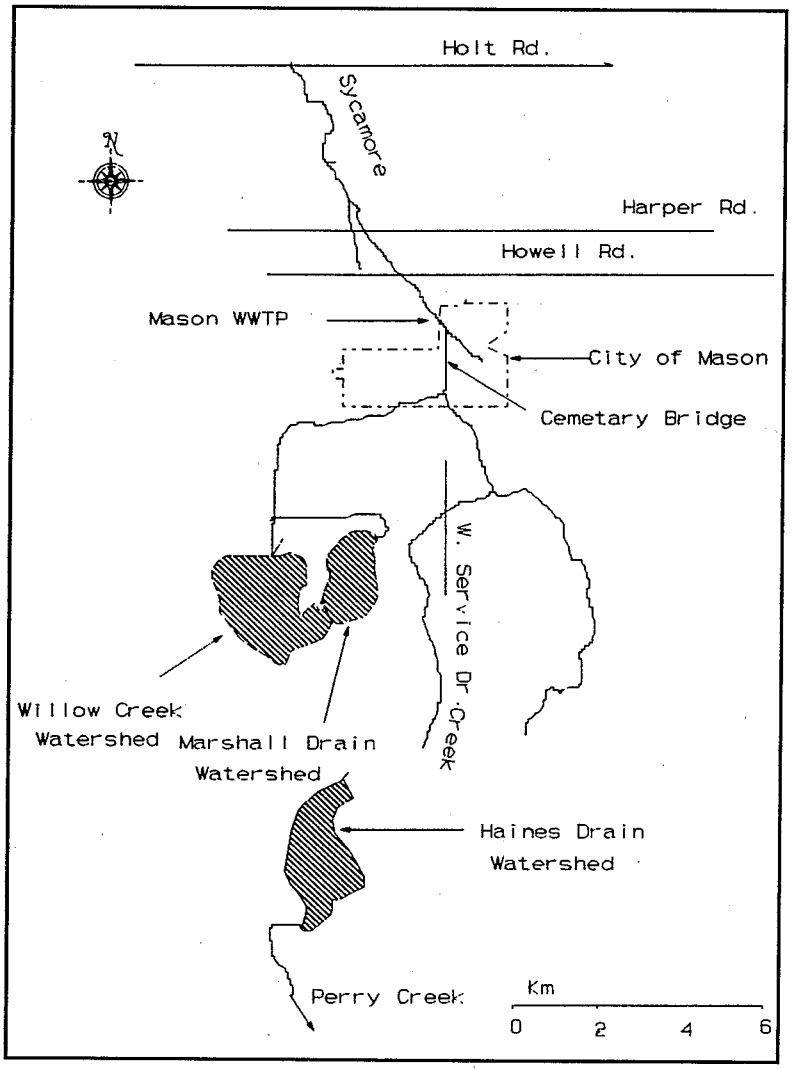

Figure 1. Sycamore Creek and vicinity.

Characterizing the Problem

Designated use impairments and DO standard violations were documented by qualitative biological surveys, channel surveys, continuous DO monitoring, and DO modeling. Biological surveys on Sycamore Creek (Clark, 1990) have revealed impaired fish and macroinverte-brate communities as evidenced by an absence of intolerant fish species and low macroinvertebrate diversity and abundance.

Most of the channels in the watershed have been dredged at least once. Channel dimensions and sediment depth were measured at 49 sites in the watershed using a survey rod and hand level. Observations of bank erosion and riparian vegetation were also made at most sites. The channel survey revealed that there is severe sedimentation throughout the watershed. The average sediment depth was 0.3 meter of mostly fine sand and silt. Active streambank erosion was occurring primarily where the banks were wooded. Ninety percent of the stations where signs of active bank erosion were noted had wooded banks. All stations where no active bank erosion was noted were nonwooded. Nonwooded sites usually had a thick sod stabilizing the bank, but in wooded sections herbaceous plants were sparse.

Continuous DO monitoring was conducted at eight locations using recording electrode style monitors. All but one site recorded DO concentrations less than the standard minimum of 5 mg/l. Three sites upstream of the WWTP that were downstream of a marsh violated the DO standard on every day monitored. At some sites DO standard violations were recorded during runoff events.

Cause and effect intensive dissolved oxygen surveys were conducted twice during 1989 to provide data to calibrate a DO model. Predictions of DO were made using a quasi steady state DO model (O'Connor and DiToro, 1970). Simulations of drought conditions were performed to determine if the DO standard would be met and to determine the relative importance of oxygen consuming factors under drought conditions. This modeling showed that most of Sycamore Creek is not expected to meet the DO standard under drought flow conditions. The primary dissolved oxygen sink under drought conditions is expected to be sediment oxygen demand followed by aquatic plant respiration (Figure 2). Model simulations show that a 52 percent reduction in sediment oxygen demand would allow the DO standard to be met at all locations except immediately downstream of the marsh.

The habitat destruction, DO monitoring and DO modeling show that sediment is the pollutant most responsible for the impairment of Sycamore Creek. Reducing sediment sources to the stream should be the goal of any corrective actions. At this time no models reliably predict effects of reduced suspended solids load on habitat, aquatic life, or sediment oxygen demand. In the absence of more precise models, the target suspended solids load reduction for a demonstration project such as this should be picked considering water

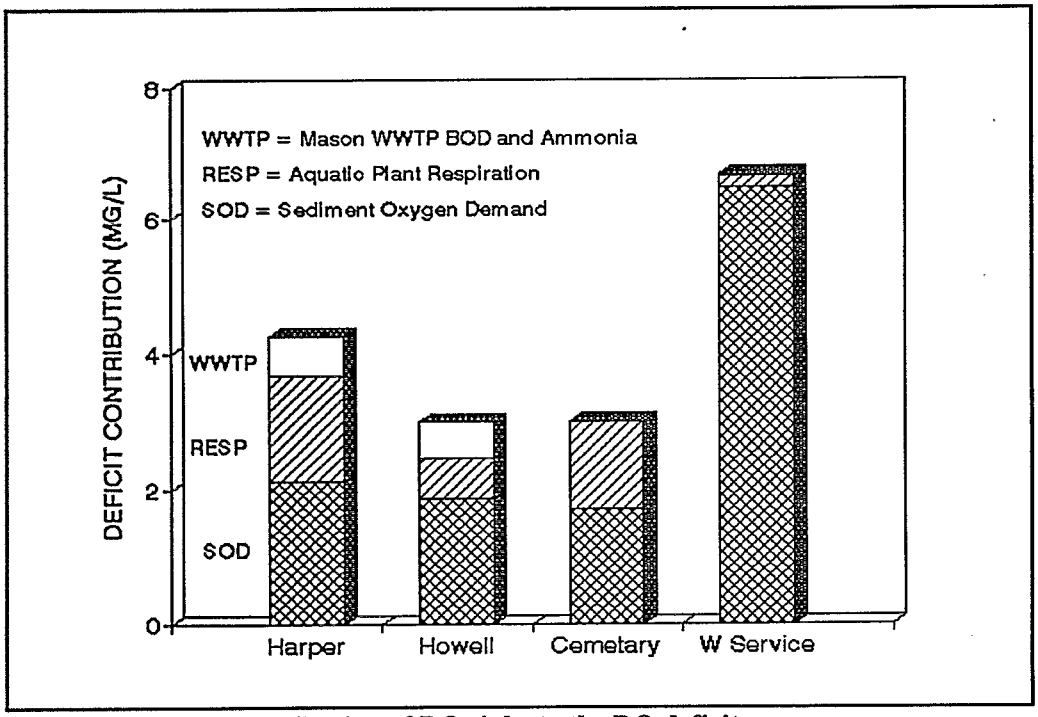

Figure 2. Relative contribution of DO sinks to the DO deficit.

quality goals, the pollutant reductions that are achievable with best management practices, and the level of pollutant reduction that is likely to achieve a significant and detectable response in the stream. Based on the assumption of a proportional response in the sediment oxygen demand by suspended solids reductions, a 52 percent reduction in suspended solids to the stream would be required to allow the stream DO standard to be met at drought flow at all locations except downstream of the marsh.

Estimating Current Sediment Loads

Agricultural Areas

Suspended solids loads from agricultural areas were estimated from an ongoing water quality monitoring program. Continuous flow monitoring and automatic sampling are being performed in three agricultural sub-watersheds (Marshall Drain, Willow Creek, and Haines Drain). Haines Drain is outside, but adjacent to, the Sycamore Creek watershed. It provides a control watershed that will allow a paired analysis for determining the effectiveness of nonpoint control strategies. This control watershed has soil, slope, and land use characteristics similar to Sycamore Creek. The monitoring season is from snowmelt (March) to the appearance of crop canopy (July). Monitoring data from 1990 and 1991 were used to estimate sediment loads from agricultural land. Monitoring is continuing through 1998 to provide an assessment of nonpoint source control effectiveness.

Pollutant loads during non-runoff periods were estimated for each of the three sub-watersheds by multiplying the average non-runoff suspended solids concentration by the total annual flow for non-runoff days in a 12-month period beginning with October 1989. Non-runoff flow during the unmonitored season was determined from a correlation to a U. S. Geological Survey (USGS) gage at Holt Road (Figure 1).

For storm runoff periods, linear regression models were derived from the data to predict individual storm loads from the peak daily average flow at the USGS gage. These regression models were used to calculate suspended solids loads from each of the three agricultural sub-watersheds for all the significant storms recorded at the USGS gage during the available 6-year period of record.

The average areal suspended solids loading rate for the three sub-watersheds was assumed to be representative of the nonurban portion of the Sycamore Creek watershed upstream of Harper Road.

Eroding Streambanks

Annual average channel erosion for actively eroding banks was determined from the product of the height, length, lateral recession rate and density of the soil in the eroding banks. Lengths and heights were estimated from the channel survey data. The lateral recession rate for a 2.6-km channel with the worst bank erosion was determined by comparing channel cross sections measured in 1989 with design criteria for the channel when it was last dredged in 1952. For other actively eroding banks in the watershed, the lateral bank recession rate was estimated from field observations. The fraction of the eroded channel soil that would travel as bedload was subtracted from the channel erosion estimates, to allow direct comparison with the agricultural and urban load estimates based on sampling that did not include bedload measurements.

Urban Areas

An urban load estimation model (Driver and Tasker, 1988) was used to predict pollutant loads from the Mason urban area. The model was calibrated for two urban subwatersheds by adjusting the bias correction coefficient to match loads measured during two moderately large summer storms that were monitored with automatic samplers and flow recorders. The calibrated model was then used to predict suspended solids loads for a 6-year rainfall record. Results for the two modeled urban subwatersheds were extrapolated to the entire urban drainage area.

Other Sources

Average annual suspended solids loads from point sources were calculated from self monitoring data. The maximum possible load of suspended solids from septic tanks was estimated from historical records of septic tank absorption field permits and some worst case assumptions.

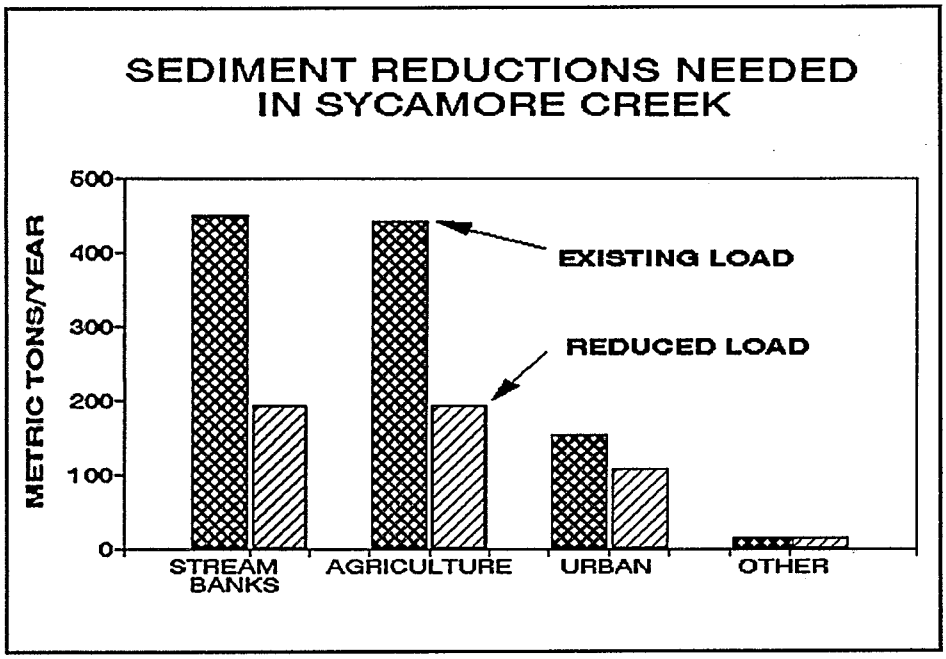

Figure 3. Existing sediment sources and recommended reductions for Sycamore Creek upstream of Harper Road.

Results of Load Calculations and Recommended Allocation

Figure 3 shows the average annual load of suspended solids from each source and the recommended reduction for each source to achieve an overall reduction of 52 percent. Other reduction strategies are possible, but the recommended strategy is reasonable and achievable by carefully targeting erosion control measures to areas with high delivery ratios such as agricultural fields adjacent to the stream, construction sites in the urban area, and the most severely eroding stream channels. This plan has not yet been approved by the Michigan Water Resources Commission. The final allocation approved by the Commission may be different from the one proposed here.

Implementation of Corrective Actions and Follow-Up Monitoring

Actions to reduce the sediment load to the stream have begun. The necessary load reductions will be achieved in part by an ongoing program of the U.S. Department of Agriculture (USDA) in the Sycamore Creek watershed. The goal of the program is a 50 percent reduction in erosion on agricultural land by targeting highly erodible land. Technical assistance is available to farmers from the USDA and the Ingham County Soil Con-servation District. In addition, cost-share money is available to farmers for the implementation of conservation tillage, critical area seedings, grass waterways, permanent vegetative cover, and other best management practices. Also, the Ingham County Drain Commissioner is seeking section 319 grant funds for the implementation of stream-bank stabilization measures in the watershed.

Follow-up monitoring is being conducted to evaluate the effectiveness of controls. Monitoring of three agricultural sub-watersheds using a paired sampling approach (Spooner et al., 1985) is being conducted to provide feedback on whether best management practices reduce sediment loads to the stream. Agricultural management practices are being documented by periodic site visits during the sampling season (approximately March-July). These land use data are being stored in the form of input files for the Agricultural Nonpoint Source (AGNPS) model. The AGNPS model output is being compared to actual runoff data for each runoff event that is monitored.

Three years of data have been collected from this monitoring program so far. Data from the first 2 years of monitoring were used to estimate loads from agricultural areas as described above. Funding will be provided by the EPA under the section 319 national monitoring program for an additional 6 years of monitoring.

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Development of the San Luis Obispo Creek Demonstration TMDL

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Section 303(d) of the Clean Water Act requires states to develop total maximum daily loads (TMDLs) for pollutants to waterbodies which will not be in compliance with water quality standards, even after implementation of technology-based treatment. Little specific technical guidance is presently available on the development of TMDLs. The objective of this project was to provide specific guidance on the TMDL development process, via case study application. This paper presents the development of a demonstration TMDL for San Luis Obispo Creek, CA. The focus of the effort was on documenting the TMDL development *process*; the San Luis Obispo site is used to show real-world considerations. Particular emphasis is given to potential problems that those developing TMDLs in the future may encounter.

The San Luis Obispo Creek Watershed (Figure 1) is located in west-central California, covering approximately 84 square miles from its headwaters in the Santa Lucia Mountains to its confluence with the Pacific Ocean at Avila Beach. The main stem of San Luis Obispo Creek is 18 miles long and flows in a southwesterly direction through the City of San Luis Obispo to the Pacific. The San Luis Obispo watershed is a rapidly-growing area. Land use in the San Luis Obispo basin includes both urban and agricultural uses, with rapid development removing a significant amount of agricultural acreage in recent years. Fertile farmlands exist adjacent to the Creek and its tributaries, producing vegetable crops, fruits, and wine grapes. In addition, cattle raising is an important activity in the area (SCS, 1984). The Creek is also used for recreational activities such as hiking, birdwatching, swimming, and canoeing. San Luis Obispo Creek provides spawning habitat for steelhead and native trout. The Creek also provides endangered species habitat for tidewater gobies (San Luis Obispo County Land Conservancy, 1988).

Several water quality problems exist within the San Luis Obispo Creek watershed. The Creek has been listed by the State of California as impaired by both sediments and nutrients. Both point and nonpoint sources are suspected to contribute to these problems. Sediment deposition is destroying spawning areas within the Creek, as well as impairing other beneficial uses. This problem extends the entire length of the Creek. Agricultural, urban, and municipal sources have been identified by the state as contributing to the sediment problem in San Luis Obispo Creek. Livestock in the riparian corridor destroy riparian vegetation and contribute to streambank erosion. Agricultural and urban runoff also carry solids to the stream. Nutrients are a problem in the Creek downstream of the City of San Luis Obispo. There are frequent algal blooms, and aquatic species change below the point of wastewater discharge to the stream. Agricultural and urban runoff are sources of nutrients, as is the wastewater treatment plant (WWTP). Total phosphorus concentrations are extremely high below the treatment plant.

Available water quality data consisted primarily of nutrient grab samples in the vicinity of the City of San Luis Obispo. Limited grab samples of solids and nutrients

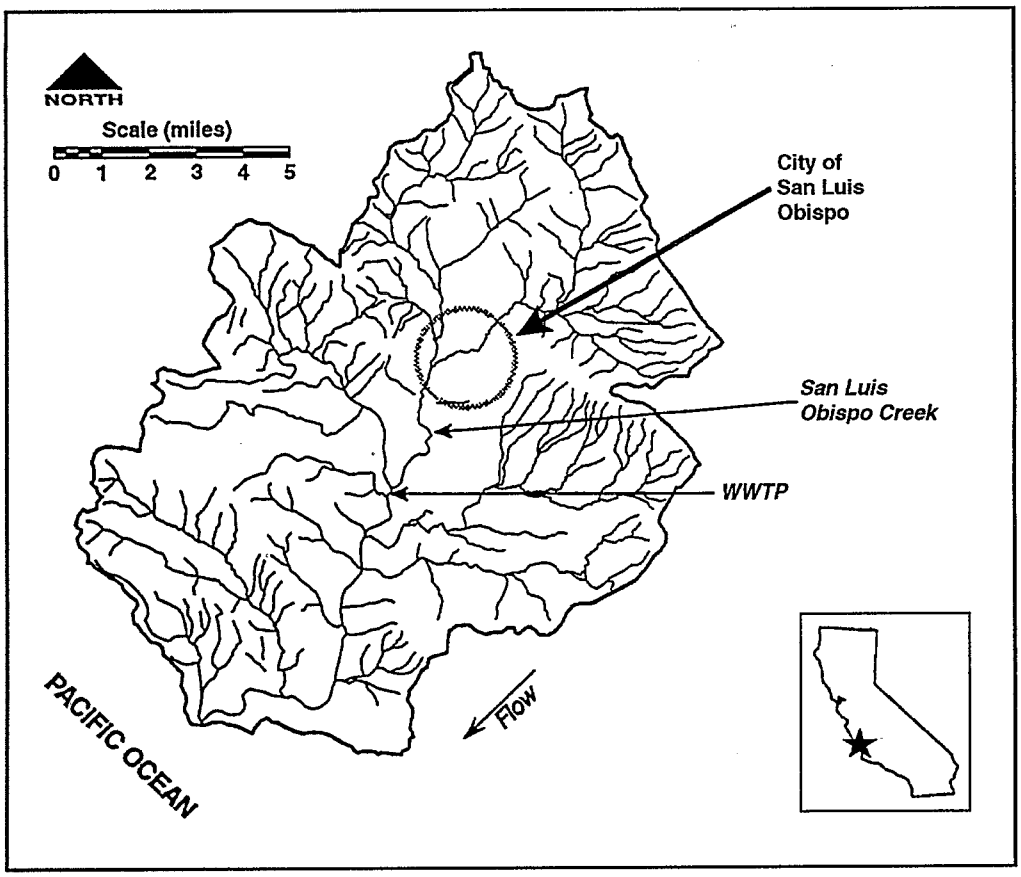

Figure 1. San Luis Obispo Creek watershed.

were also available at other locations in the watershed. Three years of continuous flow monitoring data were available at the mouth of the watershed. Discharge monitoring reports provided a thorough description of effluent quantity and quality from the San Luis Obispo WWTP. No data were available describing the magnitude of nonpoint source loads.

TMDL Approach

The TMDL development approach can take many forms, but usually contains the following steps:

1. Definition of water quality objectives.
2. Development of a model linking pollutant loads to receiving water quality.
3. Development of a nonpoint source model to predict loading under present and future conditions.
4. Preparation of an allocation strategy, which dictates the amount of load reductions required from each source category.

The TMDL approach taken for this site is shown in Figure 2 and is divided into two general steps of determining the allowable load and allocating the load between sources. In the first step, numeric water quality objectives were defined and a water quality model applied to determine the maximum allowable load which would result in compliance with water quality objectives. In the allocation step, different levels of BMP implementation and point source controls were tested until the predicted total pollutant load was in compliance with the objective.

The various analytical tools used in TMDL development (water quality model, nonpoint source model) require extensive site-specific data to be properly applied. Many waterbodies requiring TMDLs have insufficient data to allow rigorous application of the required tools. EPA (1991) has recognized this limitation, and allows for a phased approach in the development of TMDLs. The phased approach consists of a four-step process:

1. Develop a preliminary TMDL.
2. Implement control strategies.
3. Monitor to determine if water quality objectives are being met.
4. Perform detailed modeling, if necessary.

The preliminary TMDL is developed by replacing the rigorous nonpoint source and water quality models with simple (yet reasonable) assumptions regarding pollutant behavior. The control strategies identified in the preliminary TMDL are then implemented, followed by additional monitoring. These monitoring data will be used to determine if the preliminary TMDL was sufficient to bring the system into compliance with water quality standards. If the

monitoring data show the preliminary TMDL to be inadequate, these data can then be used in the application of more rigorous nonpoint source or water quality modeling. The San Luis Obispo Creek TMDL described in this paper follows a phased approach to TMDL development.

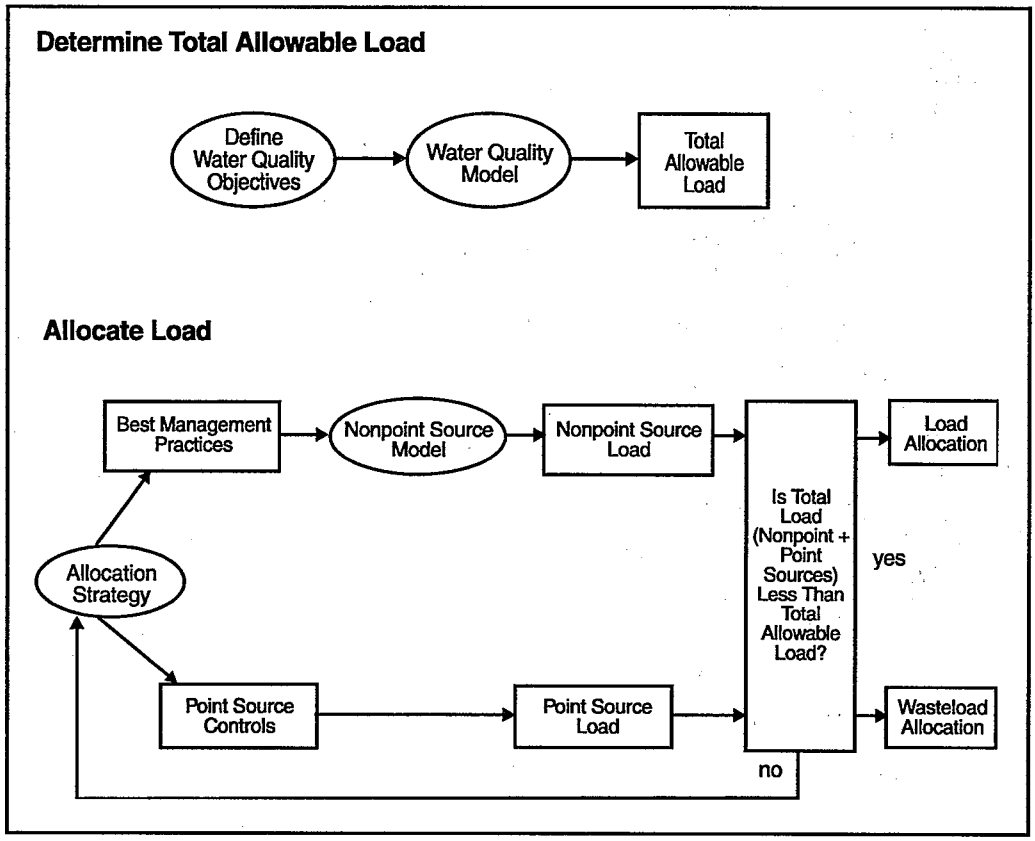

Figure 2. TMDL approach.

Water Quality Objectives

A necessary step in the development of any TMDL is the specification of quantitative water quality objectives. These are typically available for most pollutants in the form of numeric water quality standards. Numeric standards were not available for San Luis Obispo Creek for either of the pollutants of concern, suspended solids and phosphorus.

Solids are a concern because excess solids loading to the Creek has led to siltation of fish spawning sites. Setting a solids criterion is a difficult task. The objective is to maintain instream solids concentrations at a level that will prevent excess sedimentation. Unfortunately, the exact suspended solids concentration at which this occurs varies as a function of stream velocity and solids settling characteristics, and cannot be easily defined. The State Water Resources Control Board made a decision for this demonstration TMDL to decrease the solids loading to San Luis Obispo Creek by 50 percent. As part of the phased TMDL development process, future monitoring will be conducted to determine if the solids control strategy implemented for this TMDL will lead to solids levels supportive of the stream's designated use.

Nutrients are a concern because excess nutrient concentrations lead to nuisance aquatic plant growth and impair the integrity of the aquatic ecosystem. For purposes of this demonstration TMDL, an interim objective of 500 micrograms per liter (mg/l) of phosphorus was selected. This value was selected because it is representative of concentrations observed directly above the WWTP, where nutrient-related problems have not been observed.

Water Quality Modeling

The second step in the San Luis Obispo Creek TMDL development was application of a water quality model to predict instream concentrations. The objective of the model is to predict allowable pollutant loading rates which will maintain compliance with water quality objectives.

A simple dilution model was selected for use in the San Luis Obispo Creek phosphorus TMDL. No water quality model was required for solids, as the water quality objective was defined as a 50 percent reduction in loading to the stream. The instream decay rate of phosphorus was assumed to be zero (i.e., conservative

behavior). Conservative pollutant behavior was assumed because:

- Insufficient data were available to describe with confidence the fate processes affecting instream phosphorus losses.
- The assumption of no net pollutant loss will result in prediction of the highest expected instream concentration. This provides a margin of safety required in TMDL development.

The total allowable pollutant load was defined at three different locations in the Creek to ensure that water quality objectives will be met throughout the watershed.

Nonpoint Source Modeling

The third step in the San Luis Obispo Creek TMDL development was application of a nonpoint source (watershed) model to predict the total amount of nonpoint source pollutants delivered to the Creek as a function of watershed characteristics (e.g., soil type, land use) and pollution management practices. The model applied for the San Luis Obispo Creek TMDL was required to have the following characteristics:

- It could predict loads for both suspended solids and phosphorus.
- It could be applied to the wide range of land use activities present in the San Luis Obispo Creek watershed.
- The model framework was consistent with the available data.

The model selected was a linkage of the Universal Soil Loss Equation (for rural areas) and general loading functions (for urban areas). Application of these models followed EPA (1985) modeling guidance. Watershed characteristics were defined using a geographic information system (GIS) data base, to facilitate the large numbers of repetitive calculations required.

Compilation of the background data for nonpoint source model application indicated that there were 4 rural land uses, 20 soil types, 7 slope categories, and 6 rainfall erosivities. This corresponds to over 2,000 individual source areas. To facilitate this large number of calculations, the nonpoint source model calculations were conducted as part of a GIS data base. GIS data describing watershed characteristics were provided by the California Polytechnic State University (soil type, slope, drainage basins, tributaries) and the San Luis Obispo Land Conservancy (land use, cover type). Rainfall erosivities and soil erodibility were determined from soil category based upon information provided by the Soil Conservation Service. The GIS software package PC-ARC/INFO was programmed to automatically divide the watershed into discrete source areas. The software then determined whether land use was rural or urban and applied the appropriate model equation. Total loads to the Creek were determined for each pollutant by summing the loads from each individual source category.

The next step in the nonpoint source modeling effort was to define alternative best management practices (BMPs) which could be considered for nonpoint source pollution control. A review of the available literature on BMPs for the land use concerns in the San Luis Obispo Creek watershed indicated a number of BMP options. It is important to note that there was a wide range of expected load reductions associated with each BMP. Determination of the site-specific effectiveness of any given BMP requires a greater level of effort than allocated for this demonstration TMDL, so an average of observed literature values was used for each BMP. Future TMDL development projects will likely encounter similar difficulties in determining site-specific BMP effectiveness.

Discussions with the California Regional Water Quality Control Board and the local Soil Conservation Service office identified several BMPs currently under consideration in the area. These include:

- Riparian corridor restoration.
- Conversion of some agricultural lands from row crops to orchards.
- Improved agricultural practices (e.g., irrigation management, contour farming, conservation tillage).

Street cleaning and retention basins were also included for consideration as means to reduce urban nonpoint loadings.

Allocation of Allowable Loads

The final step in the TMDL development process was to allocate the total allowable load between point and nonpoint sources. This required identifying specific BMPs to control nonpoint sources and specific point source effluent limits. Little guidance is currently available on allocating allowable pollutant loads between point and nonpoint sources. Review of the watershed

model results and available data provided for the following strategy in allocating allowable loads:

- Nonpoint sources are the predominant source of solids to the stream. Efforts to achieve the solids TMDL should focus on nonpoint source controls.
- The San Luis Obispo WWTP is the primary contributor of phosphorus to the Creek. Efforts to achieve the phosphorus TMDL should consider this source. Nonpoint source reductions in phosphorus will be obtained coincidentally as part of the BMPs implemented to reduce solids loading.

The above strategy clearly defines allocation of allowable loads between point and nonpoint sources; it does not address how to choose between the available nonpoint source reduction scenarios.

A computer spreadsheet program was developed to allow the local water quality manager to determine the impact of different levels of BMP implementation and point source load reduction on attainment of water quality objectives. The user provides inputs related to both point and nonpoint source controls. The nonpoint source inputs specify the percentage of total land in different land uses that will be converted to specific BMPs. The point source inputs specify the percentage reduction of present loads required at the San Luis Obispo WWTP for solids and phosphorus, respectively. The spreadsheet described above was used to define a load reduction scenario which would lead to compliance with water quality objectives (i.e., the demonstration TMDL). It is emphasized that many different allocation strategies could be defined which would constitute a TMDL and that public input and cost/feasibility analyses are typically a required component of the final TMDL.

The top half of Figure 3 shows the TMDL calculation spreadsheet as initially seen by the user. The left half of the spreadsheet is used for model inputs, specifically the percentage of BMP application on different lands in the watershed and the percentage point source load reduction required at the WWTP. The right hand side of the spreadsheet contains model results comparing predicted pollutant loads at three locations in the watershed to loading objectives.

The bottom half of Figure 3 shows an application of the spreadsheet describing a

Land Use/BMP	% of Area in BMP Upper Basin	Lower Basin
Open Space		
Buffer Strip	0	0
Agriculture		
Controls	0	0
Orchard	0	0
Buffer Strip	0	0
Village/Urban		
Retention	0	0
Street cleaning	0	0
Rural		
Buffer Strip	0	0
WWTP TP Reduction (%)		0
WWTP SS Reduction (%)		0

	Above WWTP	Below WWTP	Mouth
New TP Load	1.6	110.6	113.6
TP Objective	1.7	7.8	9.9
New SS Load	2352	2448	6808
SS Objective	1176	1224	3404

a) Blank Spreadsheet

Land Use/BMP	% of Area in BMP Upper Basin	Lower Basin
Open Space		
Buffer Strip	0	0
Agriculture		
Controls	35	35
Orchard	25	25
Buffer Strip	40	40
Village/Urban		
Retention	30	30
Street cleaning	0	0
Rural		
Buffer Strip	25	25
WWTP TP Reduction (%)		95
WWTP SS Reduction (%)		0

	Above WWTP	Below WWTP	Mouth
New TP Load	1.0	6.5	8.5
TP Objective	1.7	7.8	9.9
New SS Load	948	1044	3293
SS Objective	1176	1224	3404

b) Completed Spreadsheet

Figure 3. TMDL allocation spreadsheet.

hypothetical set of load reductions required to achieve the TMDL. In this application, improved agricultural practices were implemented on 35 percent of the agricultural land in both the upper basin (above the WWTP) and lower basin. 25 percent of the agricultural land in the upper and lower basins were assumed converted from row crop to orchard. Buffer strips were assumed to be implemented in 40 percent of agricultural land throughout the basin and on 25 percent of the rural land in the basin. Retention basins were specified for 30 percent of the village/urban land in each part of the basin.

Finally, a 95 percent reduction is imposed at the San Luis Obispo WWTP. It is again emphasized that the scope of this demonstration TMDL project allowed only a cursory approach to allocating allowable sources. Rigorous TMDL development will require consideration of the cost and feasibility of implementing various control measures, as well as public input into the decision process.

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The Use of Geographic Information System Images as a Tool to Educate Local Officials About the Land Use/ Water Quality Connection

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Land use management is the key to improving water quality. This is particularly true for nonpoint source pollution, which cannot be controlled solely with standard regulatory permitting and enforcement techniques. In many areas of the United States, land use decisions are made primarily at the local level by a combination of elected, professional, and volunteer municipal officials. Because the cumulative water quality impacts of these local decisions can be enormous, educating municipal officials about the relationship of land use to water quality is a critical step to watershed management.

The current proliferation of laws, regulations, and technical guidance directed at nonpoint source management will further increase the need for education. As this wave of information cascades from federal to state to local agencies, the task of making this material understandable, or at least accessible, to municipal implementers has been given little consideration. Adding to these difficulties are the traditional problems associated with local volunteer decision makers (e.g., the limited time that most people can devote to this one issue in the course of their routine responsibilities, and the high turnover rate in membership typically experienced by municipal commissions).

This paper describes an ongoing pilot project in Connecticut, *Nonpoint Education for Municipal Officials (NEMO),* in which a method for dealing with this educational challenge is being developed and tested. One area being explored is the use of geographic information system (GIS) technology as a teaching tool to help others understand the links between land use and water quality.

Project Overview

Project Development

NEMO is a 3-year project funded by the U.S. Department of Agriculture Extension Service (USDA-ES) as part of a national USDA water quality initiative. NEMO and a few sister projects in the Northeast are being funded in an effort to contribute to the U.S. Environmental Protection Agency's (EPA) National Estuary Program (NEP). Under the NEP, partnerships between federal, state, and local governments, citizens, and other interest groups are established to research, characterize, and develop management plans for addressing major environmental problems

threatening estuaries of national importance. Nonpoint source pollution has been found to be a problem in virtually all of the estuaries in the NEP, and Long Island Sound, upon which NEMO is focused, is no exception.

NEMO is an outgrowth of several ongoing projects of the Connecticut Cooperative Extension System (CES). CES has staff working on water quality and natural resource planning issues, and, as part of the Sea Grant Marine Advisory Program (a cooperative venture with the Connecticut Sea Grant College Program), other staff working on similar issues along the coast. CES and Sea Grant's involvement in the Long Island Sound Study provided the impetus for NEMO.

As part of the work done under the auspices of the Long Island Sound Study Nonpoint Source Working Group, Dr. Dan Civco of the University of Connecticut conducted remote-sensing research resulting in a land cover map for the entire State of Connecticut. Satellite images were analyzed for land cover, which is principally derived from the reflectivity of the land, and the data were incorporated into a GIS. The land cover information is being used by the study in an effort to rank watersheds according to their nitrogen export to the Sound.

CES and Sea Grant staff involved with this aspect of the Study realized that the educational potential of the land cover GIS information was at least as great as its research value. With support from USDA, the NEMO project team was formed, composed of CES staff with water quality and natural resource planning expertise, Sea Grant staff with water quality and coastal zone management expertise, the GIS expertise of Dr. Civco and his students at the Natural Resources Management and Engineering/Laboratory for Earth Resources Information Systems, and Dr. Marilyn Altobello of the University's Department of Agricultural and Resource Economics.

Project Structure

Municipal officials, particularly volunteer commissioners, are the target audience of NEMO. The core of the project is an educational slide presentation that makes heavy use of GIS images. (This presentation is outlined in more detail later in this paper.)

Two other educational media will also be used in support of the slide presentation. A 12-minute educational videotape is being made which introduces the viewer to nonpoint source pollution problems and solutions. The video is being made both as part of the introductory section of the core NEMO presentation for municipal officials and with an eye to wider use for general audiences. The video is a cooperative effort between NEMO and the New York Sea Grant Extension Program. In addition to the video, a series of fact sheets are being written to provide more detailed information corresponding to the topics covered in the presentation. The fact sheets cover nonpoint source issues and management techniques and are organized by land use type (i.e., residential, commercial, etc). Much of the material is adapted from the work of the *Land Management Project* in Rhode Island.

At this point, NEMO is being piloted in three areas/towns. In order to get a wide range of experience in the applicability and usefulness of the program, towns were chosen that differed in three important characteristics: the degree of development, the type of water pollution problem of local concern, and the complexity and sophistication of town governance. A common criterion was a desire on the part of the chief elected official and/or town planner to participate in the project. Interest in the project was high. Although the project was not publicized, word of mouth resulted in more towns "applying" for inclusion in the project than could be accommodated.

Because of the way that land use decisions are made in Connecticut, it was decided to work at the town level. Connecticut has no regional or county government, and, like much of New England, municipal "home rule" is strong. As explained in the next section, this municipal orientation does not preclude a watershed-based approach. However, after working with two towns in eastern and central Connecticut in early 1993, NEMO will be applied to two small watersheds in western Connecticut, one of which is shared between two adjacent towns. This third pilot project is being jointly conducted with the USDA Soil Conservation Service, which has been doing an extensive GIS analysis of the area.

GIS as an Educational Tool

Geographic information systems allow geographically-referenced data to be manipulated, analyzed, and displayed in

ways that would be prohibitively time-consuming (or impossible) using conventional maps and overlays. Because of this, GIS is rapidly becoming an invaluable management and planning tool in a wide range of professions. GIS is often used for natural resource management applications at the national, state, or regional level. At the local level, GIS, if used at all, seems largely reserved for demographic and logistic applications such as tracking property transactions, or determining optimal bus routes. In many cases, GIS has been tried and then abandoned as expensive, overly complicated, and personnel-intensive.

NEMO's emphasis is not on the analytical capabilities of GIS, but on its potenital as a highly effective visual tool to help nontechnical citizen volunteers intuitively understand the relationship of land use to water quality in their town. It is important to note that we are not advocating adoption of GIS technology by the target towns, nor is our degree of GIS sophistication very great. While the project relies heavily on the GIS expertise of Dr. Civco and his students, all of NEMO's work is done with personal computers (as opposed to the more powerful workstation environment typical of GIS work).

The land cover data developed by Dr. Civco are the primary source of NEMO's GIS images, but other data layers are used as well. These data layers are procured from town, state, and regional planning agency sources. At this point, the project team has been lucky in that all data necessary to the program have already been digitized. For Waterford, our first target town, we are currently using hydrography, roadways, soils, topography, and town zoning. However, it is anticipated that a different set of layers may be used for each town, depending on availability and the problems at hand. For instance, in our second town, Old Saybrook, where there are ground-water problems and controversy over a proposed sewage treatment plant, the *septic versus sewered areas* layer will be an important NEMO component.

One general comment: GIS technology poses pitfalls, as well as opportunities, for educational programs. The powerful and colorful imagery creates a desire to use complicated, multilayer images, simply because you can. Our feeling is that these "GIS pizzas" are probably more effective as modern art than as educational tools. Based on this intuition and our experience in working with municipal commissions, our tendency throughout the project development stage has been to continually simplify the GIS images and shorten the slide presentation. The core NEMO presentation described in the following section now runs about 60 minutes.

The NEMO Slide Presentation

The core NEMO presentation can be roughly divided into four parts. The first part makes use of the project videotape to introduce the audience to nonpoint source pollution—its causes, effects, and management. The emphasis is on the need to change both personal behaviors and municipal policies and decision-making criteria. In addition to the video, new federal and state nonpoint source laws that focus on storm water management and coastal nonpoint pollution control programs are briefly reviewed to emphasize the need for towns to get up to speed. GIS is described in general terms.

The second section focuses on water quality and watersheds. Regional (Long Island Sound) water quality issues are mentioned, but the emphasis is on local water quality problems, both current and historical. To the extent possible, these are shown on a GIS map of the town. Examples of each major type of nonpoint source pollution (from pathogens, nutrients, toxic contaminants, sediment, and debris) are illustrated with local photographs. Following the water quality discussion, the water cycle and the watershed concept are introduced. It is here that the project makes the first real use of GIS technology—town and regional hydrography, drainage basin boundaries, and topography are used to show how and why water systems are connected. The initial reaction of the NEMO team and other observers is that these three-dimensional images are very effective in communicating the concept of watersheds and the need for watershed management.

The third section of the NEMO presentation focuses on land cover/land use. The original satellite photography and its resultant 24-land cover analysis are shown and explained. Although in general the program does not explain the technical background or analytical techniques behind the GIS data, the difference is explained between *land cover* (derived by reflectivity

from what is seen by the satellite) and *land use* (what is zoned or planned for a given area).

The 24 land covers are then condensed into six basic categories, approximating traditional land use types that municipal commissioners are familiar with: commercial and industrial land, water, roadways, residential land, agricultural and open land, and forested and wetland areas. GIS images of the town are shown highlighting each of these "land use types." The images are interspersed with local aerial and ground-level photographs, followed by word slides summarizing characteristic nonpoint source problems and management options associated with each land use type. More detailed information on these topics is contained in the fact sheets.

The last part of the NEMO project focuses on impervious surfaces. A growing body of evidence suggests that there is a linear relationship between the amount of impervious surface in a given watershed, and the impairment of water quality in the receiving stream of that watershed (Klein, 1979; Schueler, 1987 and 1992; Schueler et al., 1992). Existing land use (the six-category GIS information) is used as the basis for estimating the present degree of imperviousness of watersheds draining to key town water resources, such as a coastal cove or a reservoir. This is compared to a *buildout* analysis of imperviousness based on the zoning regulations of the town, assuming a scenario of 100 percent development to zoning specifications (for instance, that all land zoned as residential will be developed as such). The analysis is applied only to land available and suitable for development (i.e., all dedicated open space, wetlands, and other nondevelopable areas are removed from the buildout scenario). The resultant estimates of current and future levels of imperviousness are calculated and displayed by watershed, which we feel is the most appropriate and useful way to consider the implications of the data.

It is not within our capabilities at present to estimate amounts of impervious surface directly from the satellite-derived land cover data. Therefore, both current and future estimates use literature values for the percent imperviousness of given land use types, using the land cover data and the zoning regulations, respectively, as the basis to which these values are applied.

By showing which watersheds, and which sub-basins within these watersheds, are likely to experience dramatic increases in the amount of impervious surface, NEMO allows local officials a "quick and dirty" look at the present and future effects that their land use plans and policies might have on their town's water resources. With this knowledge in hand, the project team can suggest a number of options for the town. Best management practices, site plan considerations, maintenance policies, zoning changes, and other techniques are briefly outlined. These options are covered in greater detail in the NEMO fact sheets which, in turn, contain reference lists. It should be noted that the program does not act as a consultant and offer specific solutions—these are left up to the town officials. However, detailed follow-up seminars on such topics as best management practices or soils-based zoning will be available to interested commissions, and hard copies of key GIS images and analyses will be left with the town officials for future use.

NEMO's emphasis on impervious surface is admittedly simplistic. NEMO is an educational program and is not designed to take the place of technical guidance. It is, however, our hope that the simple yet scientifically valid relationship between impervious surface and water quality can be used as an underlying theme that town officials can understand and remember during the course of their day-to-day processing of site development applications. The danger of over-simplification pales in comparison to the danger that, faced with an avalanche of technical guidance and regulations from an army of agencies, local officials will be too confused and intimidated to act at all.

Project Status and Future

The NEMO program is scheduled to be conducted in the first target town in April 1993. Obviously, there is no way yet to evaluate either the effectiveness of the educational program or its implications as a model for wider application. Even so, developmental work is being done to expand upon the original project, in terms of both geographic scope and application of GIS. More detailed GIS analysis, and larger, multijurisdictional watersheds (perhaps bistate watersheds) are being discussed with the CES and Sea Grant programs in both Rhode Island and New York, and the National Sea Grant College

Program has expressed interest in working with USDA-ES on advanced pilot projects.

It is difficult to tell whether or not a model project of this type can ultimately craft a program capable of overcoming the twin obstacles of commission turnover and (for lack of a better term) attention span. To do so, a program must be simple, inexpensive, and easily implemented, yet effective. However, several trends in the GIS industry, including the proliferation of digital natural resource data, the dropping costs of computer hardware, and the development of user-friendly GIS "browsing" technology (which allows users to manipulate and display existing data sets), make us think that we are heading in the right direction. By retaining our focus on devising an effective educational package, rather than on providing technical guidance or using our GIS capabilities primarily for data analysis, we hope to emerge with a program of practical use to local decision makers, and therefore be effective in helping to manage nonpoint source pollution.

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Using Geographic Information Systems to Develop Best Management Practice Programs for Watershed Management: Case Studies in the Delaware River Basin

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A geographic information systems (GIS) approach has been used in the evaluation of two different watersheds in southeastern Pennsylvania, the Neshaminy Creek Watershed and Upper Perkiomen Watershed, both within the Delaware River Basin (Figure 1). In both cases, the study objective was to facilitate technical evaluations through use of GIS technology and then to develop watershed-wide recommended management actions to accomplish water resources objectives. In the more intensive Neshaminy study, a detailed pixel/raster format was used for the GIS to support detailed hydrologic modeling and water quality analysis. The Neshaminy Project, part of Pennsylvania's Act 167 Storm water Management Program, had as a requirement that technical findings be translated into real-world subdivision regulations to be adopted by all of the 30 watershed municipalities. On the other hand, the Upper Perkiomen study, by design, was less detailed both in its GIS approach and in the level of management recommendations which evolved. The projects together indicate that the level of detail in the GIS approach selected necessarily should take into account the specificity of the outputs which are needed—in this case, management actions to be implemented watershed-wide.

Case Study One: Neshaminy Creek Storm Water Management

Context of Project

The Neshaminy Project was mandated by the 1978 Pennsylvania 167 Stormwater Management Act, requiring that counties prepare storm water management plans for all watersheds in the state. After counties have prepared the plans, including special storm water management standards and criteria, then local municipalities must implement them, through adopting the necessary ordinances and regulations. In the case of the Neshaminy, the Bucks County Planning Commission prepared the storm water plan with Cahill Associates as technical consultants. The Watershed included all or portions of 27 different municipalities within Bucks County, as well as another 7 municipalities within Montgomery County. Adoption of storm water plan elements was made especially challeng-

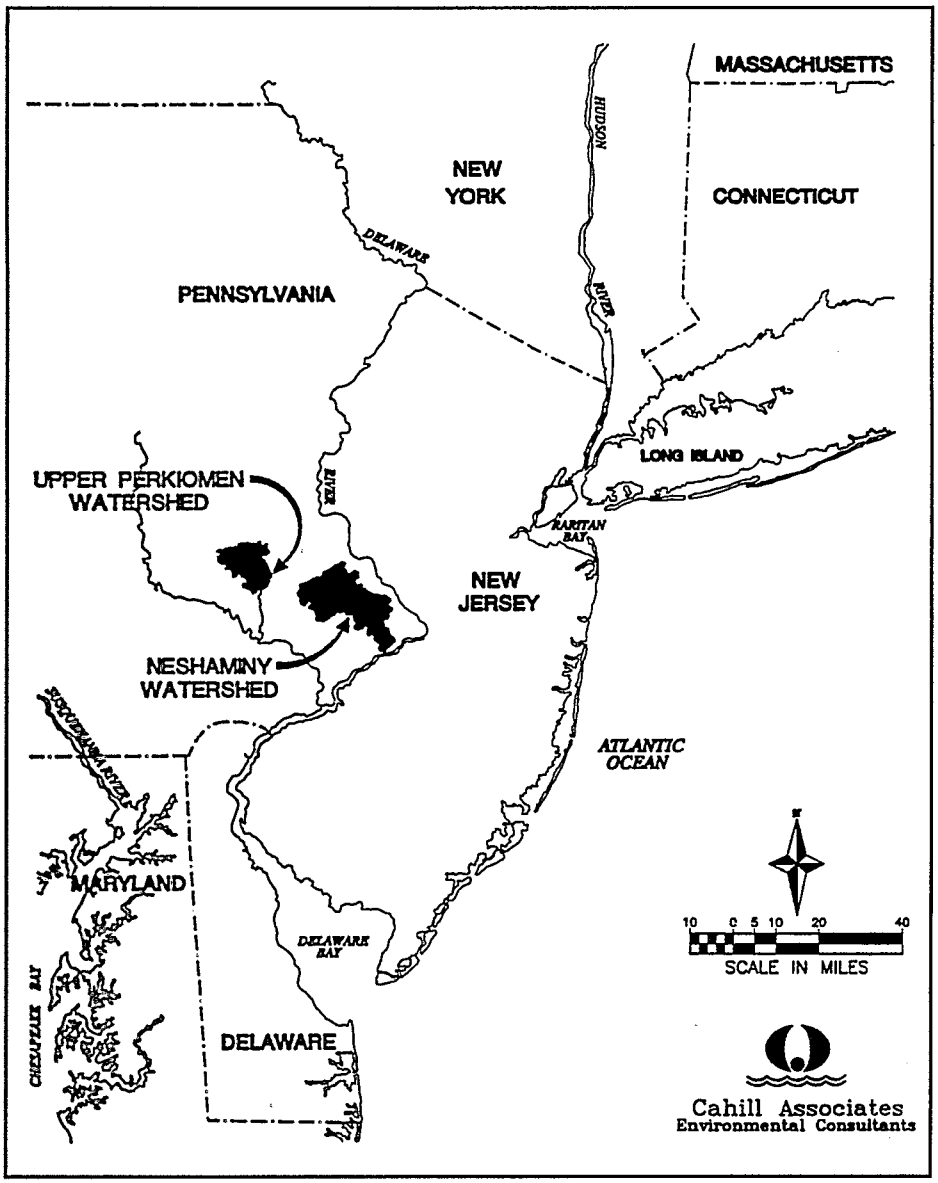

Figure 1. Regional location of Neshaminy Creek and Upper Perkiomen Creek Watersheds.

The Neshaminy Project had several water resource management objectives:

1. Prevention of worsened flooding downstream, caused by increased volumes of runoff from land development.
2. Increased ground-water recharge.
3. Reduction in pollutant loadings.

When this storm water management program was conceived, the state's focus was prevention of flooding. Because detention basins have become the primary mode of storm water management in most communities and because detention basins, while controlling peak rates of runoff, result in significant increases in the total *volumes* of water discharged from sites, increased storm water volumes have combined to create worsened flooding, especially acute in the hilly regions of Pennsylvania. Consequently, the thrust of much of the Act 167 planning has been elaborate hydrologic modeling, performed throughout respective watersheds.

In the case of the Neshaminy, however, the initial perception and record suggested that although localized flooding could be an issue here, an existing network of multipurpose flood control structures constructed during the 1960s served to prevent significant flooding. However, water quality certainly was a concern, especially in the reservoir system. And the issue of increased volumes of runoff—and decreased amounts of precipitation being infiltrated into the ground water—was a concern because a significant portion of the Watershed relied on ground water for water supply. Consequently, the Neshaminy Creek Project established objectives which addressed these more comprehensive water resource concerns.

ing by the fact that exclusive land use planning and control occurs in Pennsylvania on the municipal level. In other words, the Neshaminy Watershed included 33 different planning commissions with 33 different comprehensive plans and zoning ordinances, 33 different governing bodies with 33 different sets of subdivision regulations, and so forth. Such a structure makes the problem of storm water management—communicating its various dimensions and attempting to formulate and implement technical solutions for 33 municipalities—a tremendous challenge.

Neshaminy Watershed Setting

The Neshaminy Creek Watershed includes 237 square miles of mixed urban and rural land uses, primarily in Bucks County, PA. The Neshaminy flows directly into the Delaware River and includes a network of eight existing impoundments, some of which are multipurpose with permanent pools and provide critical recreational functions for a burgeoning Bucks County population. At the same time, the proliferation of development which had occurred in the watershed, with its increased point and nonpoint sources, had degraded streams and seriously impacted the artificial lakes and reservoirs. Although the total water resources of the Neshaminy Watershed certainly were the primary concern, the future of these special lakes and reservoirs came to be of particular importance in developing the total storm water management program for the Neshaminy Watershed.

The Neshaminy Watershed has already been heavily developed, although farmsteads and large areas of undeveloped land still existed. Many headwaters areas were largely undeveloped. The Neshaminy comprises the heart of Bucks County, Pennsylvania's primary population and employment growth county. Although agriculture was a major land use in the past, farms rapidly were being converted to urban uses as the wave of urbanization continued to move outward from Philadelphia and from the Princeton/Trenton metro areas. In the lower (southern) portions of the watershed were older river-oriented towns, developed at high densities with much of their manufacturing base now in decline. In the central Watershed areas (Doylestown, Newtown, Oxford Valley, Trevose) were vast proliferations of residential subdivisions punctuated with large office parks and mall retail centers, located along major highways and expressways (Pennsylvania Turnpike, US 1, US 202, US 611, PA 309, and others). During the 1980s, large portions of many of the municipalities here underwent "buildout." Growth projections indicated continuation of this rapid growth with substantial increase in impervious surfaces.

Physiographically, the watershed spanned both the Piedmont and Atlantic Coastal Plain provinces. In the upper headwaters areas of the Piedmont, the rolling topography included relatively steep slopes. Geologically, the watershed consisted primarily of Triassic formation rock, including the Lockatong, Brunswick, and Stockton formations, although diabase intrusions, areas of carbonate formations, and other geological types also were important. The Triassic rock ranges from being a poor aquifer (typically the Lockatong) to an excellent aquifer (many areas of the Stockton) where the many rock fractures allowed for considerable groundwater yields. Soils were quite variable, ranging from good loamy prime farm types (Hydrologic Soil Groups A and B) to the more problematic clayey types with poor drainage characteristics (high water table, shallow depth to bedrock, and so forth). Most of the soils in the watershed fell within Hydrologic Soil Group C, making them marginal for many storm water management recharge techniques.

Hydrology of the watershed had been altered by a system of storm water control structures, constructed under the federal P.L. 566 program, which worked to prevent flooding especially from larger storms. Of the base average annual precipitation of 45 inches per year, about 12 inches (26.7 percent) was recharged into the ground water to become stream baseflow, about 10 inches (22.2 percent) ran off immediately, with the sizable remainder being either evaporated or transpired by vegetation (Figure 2). As specific conditions such as soil type and existing land cover varied in different sub-areas, these proportions also varied. For example, in heavily developed portions of the Watershed, impervious surfaces combined with numerous detention basins prevented the bulk of the precipitation from being recharged, and total runoff was proportionally increased in volume. An elaborate system of municipal and nonmunicipal wastewater treatment plants discharged effluent which, in some cases, comprised the bulk of the stream flow during dry periods.

Hydrogeology of the watershed was such that surface water and ground-water basins coincided to a large degree. There were no large aquifer systems moving significant amounts of water into or out of the watershed, as one might encounter in other geological contexts. Most stream baseflow emerged usually in a matter of days or weeks after moving down perhaps a couple of hundred feet and perhaps a few thousand feet laterally to the receiving stream. Maintaining this natural hydrologic

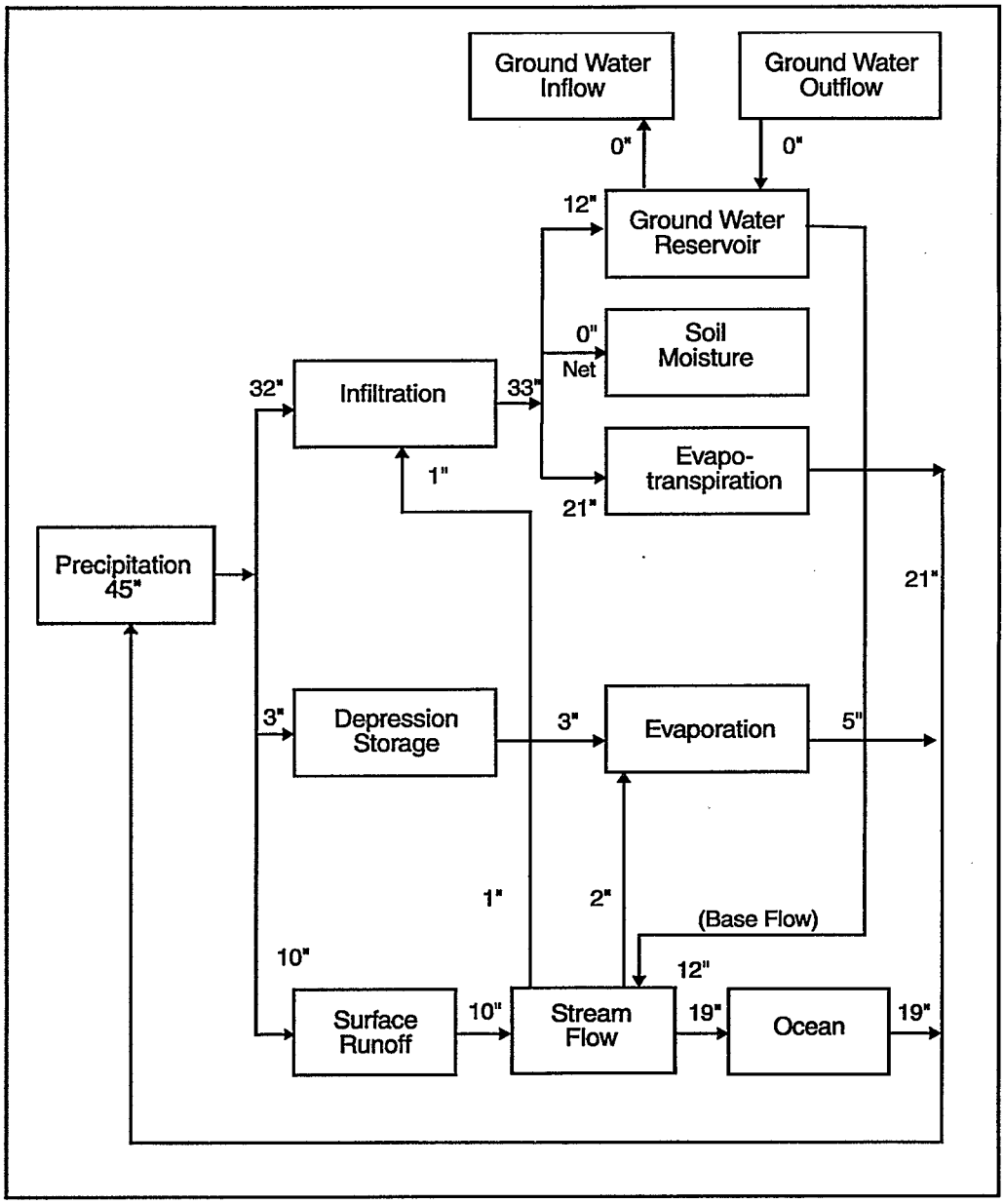

Figure 2. Neshaminy Creek Watershed hydrologic cycle.

regime became an important storm water management planning objective in order to maintain stream baseflow especially in small tributaries.

GIS Approach

The GIS developed for the Neshaminy was dictated by PA Act 167 and the hydrologic and other modeling used to support this total planning process. The GIS included a 1-hectare-sized pixel format (49,255 pixels) to encode natural and man-made features such as soils series, slope, existing land use, future land use, hydrologic sub-basins, and other data files. Development of these different data files required major effort. The GIS was used to calibrate and verify the hydrologic model (TR-20), using the Soil Conservation Service (SCS) "cover complex method" for runoff analysis. Curve numbers based on land use/land cover and soils series combinations were calculated for each of the 49,000 cells and weighted for each of the 100 different sub-basins designated in the watershed. A data file containing stream channel characteristics with overland flow characteristics by sub-basin also was created. A program was developed to generate for each sub-basin estimates of overland travel time and channel travel time. Hydrographs were computed, combined, and routed through the sub-basins and to the tidal portions of the Neshaminy, taking into account existing storm water management embodied in detention basin design and, of course, the real hydrological effects of the in-place flood control structures (i.e., the eight P.L. 566 dams). The U.S. Department of Agriculture-SCS TR-20 model was selected for analysis in this Project because other hydrologic models tended to use generalized runoff factors by sub-basin, rather than evaluate in detail the spatial variability of land cover and soils. TR-20 also more accurately simulated the flood wave with regard to actual flow, integrating component hydrographs from different sub-basins so that analysis could be analyzed by sub-basin, by groups of sub-basins, or by total basin. The ability

of the model to focus on specific sub-basins was vital because output had to be disaggregated to 33 different municipalities comprising the watershed. In a separate analytical process, nonpoint source pollutant loadings also were estimated by pixel, based on assignment of pollutant loading factors which had been estimated from a combination of previous studies and Watershed experience. Cahill Associates developed software designed specifically for this project, all of which was conveyed to Bucks County Planning Commission (BCPC).

As with the soils data (discussed below), the approach given to creation of both existing and future land use data files in the Neshaminy Project was quite detailed and fine-grained, reflective of the planning requirements established in the Act 167 program as well as the outputs needed for the management program. For example, detailed municipal population projections were used from the regional planning agency, disaggregated into households, and then loaded into each of the 33 municipalities, on vacant and developable parcels and in accord with official zoning maps. Nonresidential growth was similarly projected. This complicated, highly informed process produced detailed maps of future development, which then were converted into the hectare-based data base. When combined with other data files such as the soil data, such a level of refinement provided the potential of "testing" different storm water management standards and criteria being proposed, municipality by municipality. Because these standards and criteria were both unconventional and controversial, such testing for reasonableness was essential, if the 33 different municipalities were to be expected to implement this new program and adopt new ordinances compatible with these new storm water requirements. *The ability to demonstrate technical feasibility was critical in terms of assessing future legal challenges and overall acceptability.*

The detailed nature of the land use data files also had to take into account the complexity of the watershed, its existing land use patterns, and the manner in which growth was projected to occur. Analysis of the then-current air photos used to develop the existing land cover/land use data file indicated that although much of the watershed was substantially developed, there did exist a large number of vacant developable tracts of land. In many cases, the projected or future land use data file assumed that these tracts would be developed. Because of this "grain" of activity, an appropriately detailed data base at a 1 hectare/2.4 acres pixel cell size was selected.

Furthermore, other Act 167 provisions reinforced the need for such a high resolution data base. As specifically set forth by Act 167, new storm water management program requirements had to be implemented by municipalities on all new land development. In Pennsylvania, such a process occurred during the course of the municipal review of each new land development, parcel by parcel. Although in some cases individual proposed land developments were large, consisting of hundreds of acres, the vast majority of the developments were not that large. Most new residential subdivisions in the watershed had been and most likely would continue to be less than 25 acres. Consequently, storm water management was actualized on this small scale, and new requirements would be undertaken on such a small scale as well. Feasibility of new requirements had to be demonstrated on this same small scale, which required manipulation of a relatively detailed or "fine-grained" data base.

Soils types and related underlying geology of the watershed were factors critical in development of the storm water management program requirements. Consequently, both factors were included in the data base. Soils features were developed in detail, including their Hydrologic Soil Group rating and characteristics related to the soils ability to infiltrate precipitation (i.e., the soils recharge potential). This soils information became essential in the determination of storm water standards and criteria to be required and the best management practices (BMP) which would be necessary to achieve these standards and criteria.

GIS Use in Watershed Management

In the Neshaminy, both water quantity and water quality impacts of storm water were deemed to be important management issues. Nonpoint source pollutants had significantly impacted the existing Neshaminy impoundments and their uses. Selected storm water management techniques, including infiltration technologies and a minimum disturbance/minimum maintenance approach to land development, were identified as offering important storm

water management potential. However, soils limitations and other factors made selection of these different BMPs less than straightforward. The GIS was used to evaluate feasibility of different BMP applications together with their relative effectiveness for both peak runoff and nonpoint source pollutant load reduction, especially insofar as future land development was concerned.

A BMP Selection Methodology (Figure 3) was developed to be incorporated into the respective codes of the 33 different municipalities within the Neshaminy Creek Watershed, as required by Pennsylvania State law. This methodology, focusing on new land development applications submitted to these 33 municipalities, was designed to take into consideration both water quantity and water quality concerns. The method specified an array of BMPs, most of which were structural in nature. BMP selection was to be a function of several factors, including the need for further peak rate reduction, the recharge sensitivity of the project site (defined as a function of headwaters stream location, areawide reliance on ground water for water supply, or presence of effluent limited streams), and the need for priority nonpoint source pollution controls (location within impoundment drainage). Two levels of BMP selection were developed: the minimum Required and the more fully effective Recommended. The Selection Methodology also was made sensitive to type of land use or development being proposed, with the typical single-family residential subdivision being assigned different BMPs than, for example, multi-family proposals and other nonresidential proposals (including commercial and industrial proposals). Size of site also was determined to be a factor to be included in the selection process, differentiating between sites of five acres or more because of the varying degrees of cost and effectiveness of different BMP approaches. In sum, the Methodology was driven by the need for environmental

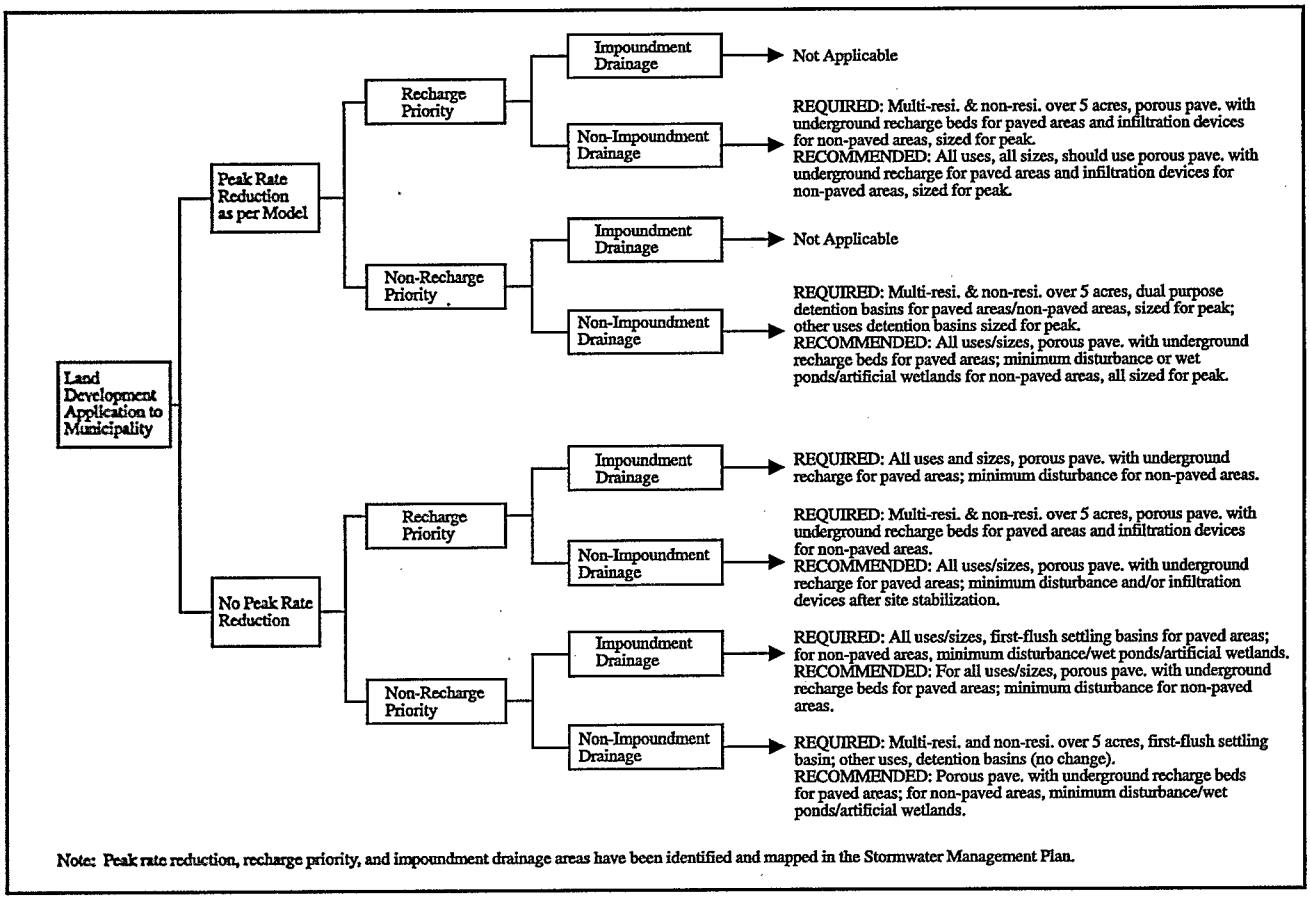

Figure 3. Proposed best management practices selection methodology decision matrix.

performance together with the need to be legally and economically justifiable, within the Pennsylvania municipal context (political acceptability, of course turned out to be another matter entirely; it should be noted here that the final program which evolved and now is being implemented underwent change and is not the same program described in this paper). Ultimately, the BMP Selection Methodology was intended to be written into respective municipal ordinances (typically, the subdivision regulations) with localized provisions being included as necessary. The Methodology, if properly and fully implemented, was designed to achieve the necessary storm water-related objectives—both quantity and quality—which the analysis had deemed to be necessary.

The GIS was especially important in being able to test the reasonableness of this total Methodology. Such tests included evaluating, municipality by municipality, the nature and extent of the development being projected together with size of development/size of site assumptions together with other vital BMP feasibility factors such as soils and their appropriateness for different BMP techniques. In certain cases, such testing indicated the need to further refine the Methodology, possibly through simplification in those municipalities where some of the Methodology factors were not appropriate. For example, if projected growth occurred on areas with soils predominantly *not* suitable for infiltration BMPs, modifications in strategy would have to be made in that particular municipality.

The GIS enabled analysis of the water quantity and quality impacts of projected growth on a baseline basis, assuming continuation of existing storm water management practices. Water quality loadings to individual impoundments and to the stream system could be readily demonstrated. Because overenrichment of the impoundments was so crucial, phosphorus and nitrogen loadings from projected development assuming existing storm water practices could be estimated, even on a municipality by municipality basis. *The ability to isolate pollutant loadings by municipality and to make explicit these water quality impacts or the amount of ground water recharge being sacrificed was an important factor, legally and politically, in being able to "sell" an innovative program to the many different groups involved here.*

Case Study Two: The Upper Perkiomen Creek Watershed Project

Context of Project

The Upper Perkiomen Creek Watershed Water Quality Management Project evolved as the result of interest by the Delaware Riverkeeper/Watershed Association of the Delaware River, a private nonprofit environmental organization dedicated to promoting the environmental well-being of the Delaware River Watershed. The Project was funded by one of the major industrial point source dischargers in the watershed, Brown Printing, Inc., a nationwide printer of magazines and other materials. Because of this unusual origin, the Project was not rigidly defined or constrained by a specific set of government regulations or guidelines and was free to evolve as deemed appropriate by those directing the work. The water quality management issues which were addressed ultimately were approached from a more macro-scale perspective, when contrasted with the management program which emerged in the Neshaminy Project.

Watershed Setting

The Upper Perkiomen Creek Watershed (Figure 4) had both interesting similarities and differences when compared with the Neshaminy Creek Watershed. Like the Neshaminy, water resource-related problems in the Upper Perkiomen, a tributary of the Schuylkill River in the Delaware River Basin, included water quality, particularly pollutant loadings to a large raw water storage reservoir (Green Lane Reservoir) which was experiencing eutrophication. Adjacent to Green Lane Reservoir were two small impoundments, Deep Creek Lake and Knight Lake. These waterbodies received heavy recreational use and were located within regionally-important Montgomery County park facilities. Like the Neshaminy, the 95-square-mile Upper Perkiomen Watershed was blessed (cursed?) with a multiplicity of local governments, including 4 different counties and 18 different municipalities. Unlike the Neshaminy, however, the bulk of the Upper Perkiomen Watershed was still quite undeveloped and rural in nature. Many headwaters were of very high water quality.

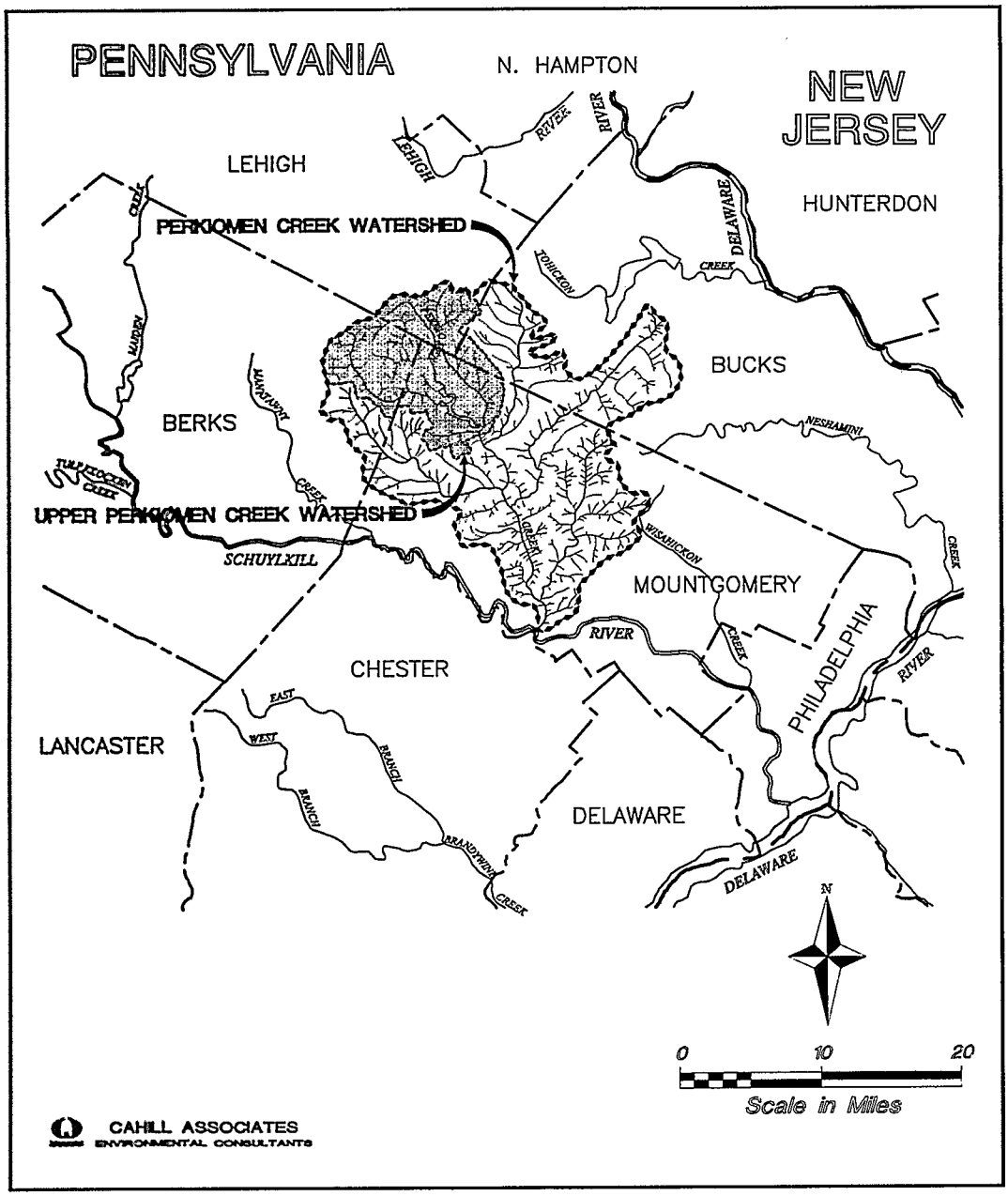

Figure 4. Upper Perkiomen Creek Watershed.

Located entirely within the Piedmont physiographic province, geological formations resembled the complex geology of the Neshaminy (Figure 5). Many areas were Triassic in origin (especially the Brunswick and Stockton formations). Areas of diabase were identified, as were areas of carbonate formations. Soils were similarly variable, ranging from some excellent prime agricultural classes to thin cover on steep slopes with substantial rock outcroppings. Moving into headwaters areas, the Watershed tended to become more steeply sloping. Most soils here were of Hydrologic Soil Groups B and C, with permeabilities varying from good to bad and pollutant removal capabilities equally variable (Figure 6; as soil permeability *increases*, pollutant removal capability tends to *decrease).*

The Upper Perkiomen Watershed, located on the extreme fringe of the Philadelphia metropolitan area, basically escaped the growth surge of the 1980's. Consequently, the frequency of new residential subdivisions and other manifestations of suburban sprawl were found to be relatively rare. The heart of the Watershed consisted of several older historic boroughs, linked together in a lineal pattern. Much of the existing housing was turn-of-the-century at quite high densities, mixed together with a variety of commercial and other uses, a pattern contrasting sharply with what has become typical in so many suburban areas. These boroughs resembled the "village" concepts being advocated by innovative planning theorists in a variety of important ways.

Population projections and other growth indicators suggested that additional development would occur at varying rates throughout the Watershed. One critical

municipality had undertaken a strongly pro-growth planning process which included construction of new sewage treatment plants with substantial high-density residential and nonresidential development just upstream from the Green Lane Reservoir. In this context, new sewers could induce build-out of entire sub-watershed areas in a few years. In other words, although overall projections for the area indicated moderate levels of development on average, a municipality's approach to managing its portion of the watershed could have dramatic land use and, therefore, water quality consequences.

Farming, both crop cultivation and dairying, was found to be a major existing land use in the watershed, although agriculture here was not especially robust and seemed to be losing ground. Dairying had declined in recent years. This lack of prosperity came to be a major factor in determining the manner in which additional management measures could be imposed on agricultural pollution sources. Much of the watershed, especially the steeply sloped and igneous rock areas in the headwaters, remained in forest cover.

Many streams in the upper portions of the watershed were found to be of excellent quality, providing trout habitat and a generally vibrant aquatic resource. A few municipal wastewater treatment plants and several industrial point source dischargers were identified, mostly in the lower portions of the watershed. Agriculture was determined to be the major nonpoint pollutant source, although the developed land uses (both urban and suburban areas) certainly contributed their share of pollutants to the system. The

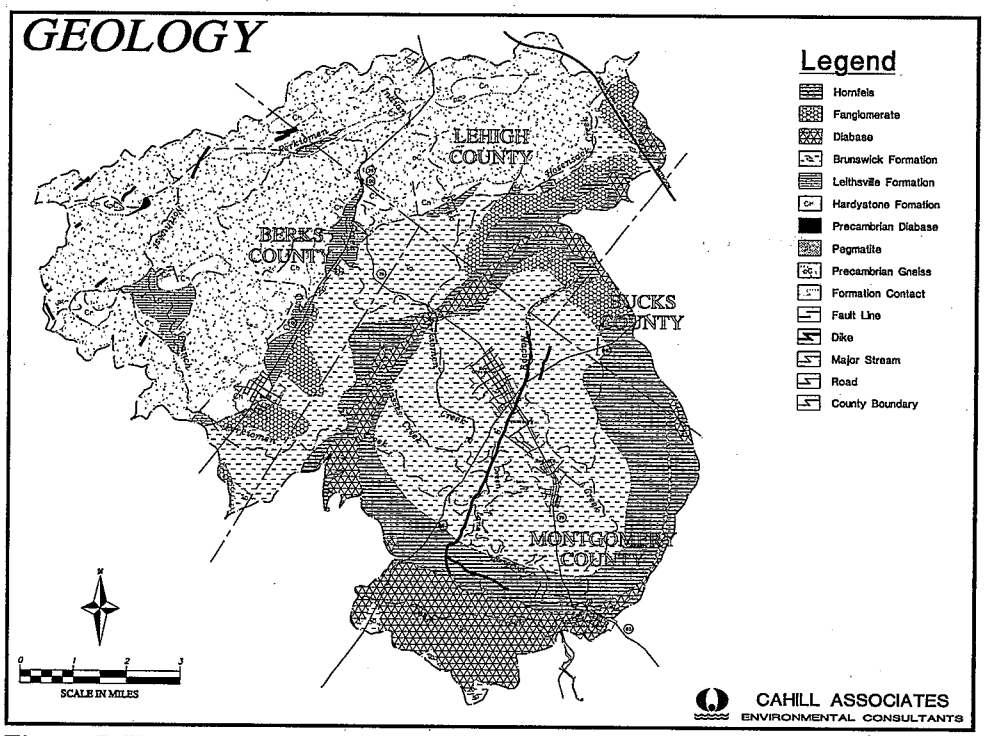

Figure 5. Upper Perkiomen Creek Watershed geology.

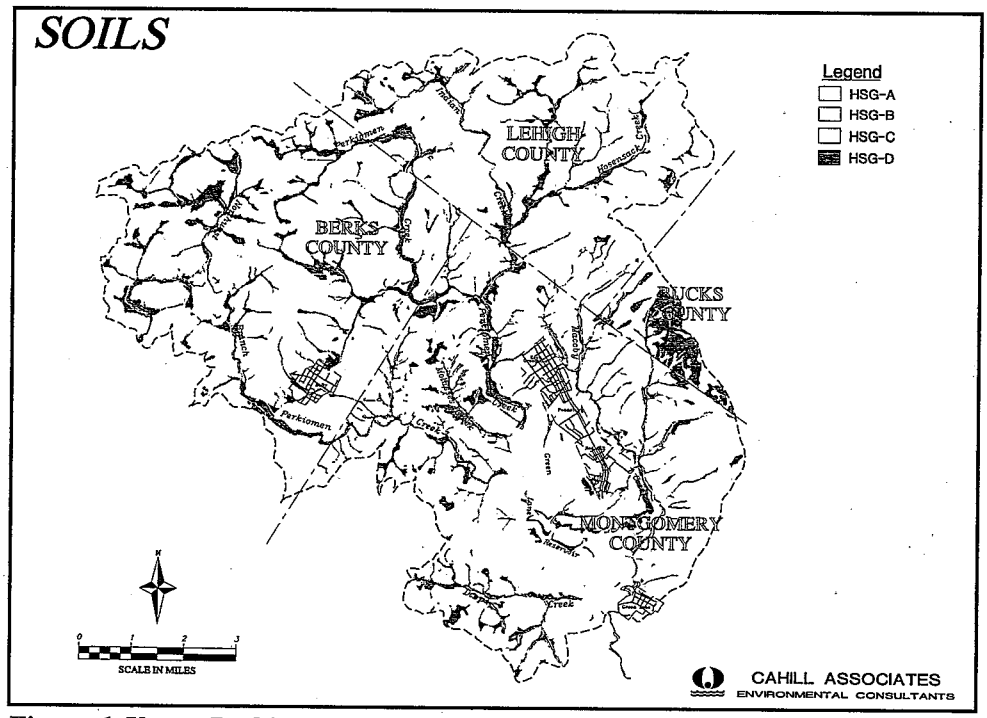

Figure 6. Upper Perkiomen Creek Watershed soil types.

primary waterbody, the Green Lane Reservoir, was highly eutrophic. The adjacent Deep Creek Lake, used for swimming at the popular Montgomery County park facility, also suffered from overenrichment and recent occurrences of bacterial contamination, attributed to numerous malfunctioning on-site septic systems upstream. In sum, although many streams themselves were still of good water quality, the reservoirs accumulated and magnified existing pollutant loadings. The need for better watershed management in the future in order to prevent far more serious problems from occurring as development continued was apparent.

GIS Approach

The major focus of this project included innovative use of GIS technology and computer system capabilities to analyze watershed characteristics and their impact on water quality management. The GIS was used to estimate pollutant loadings by source (both existing and future) and then to develop watershed-wide management actions which emphasized preventive nonstructural practices, especially for nonpoint source pollution control.

The Upper Perkiomen study utilized GIS recently developed software (ArcCAD) for geographical information system design, development, and analysis. ArcCAD, a polygonal-based system, allowed the advantages of the ARC/INFO and the AutoCAD system technologies to be combined. This GIS system provided an efficient method for both evaluating the causes and mechanisms of pollutant transport and aided in the selection of suitable management measures to reduce or eliminate pollutant inputs. GIS data files were developed for geology, soils, municipality, and land use/land cover, as well as sub-watershed areas developed for the water quality modeling. File creation was expedited by the ability to encode areas in the form of polygons of developed areas (Figure 7), in contrast to the pixel-specific approach used in the Neshaminy Project. In the case of the geology file, for example, the entire watershed could be digitized in a matter of hours. Land use/land cover was based on high-altitude aerial photography and encoded as polygons, in a manner requiring a fraction of the time necessary for the Neshaminy file preparation. Special care was taken in the preparation of the agricultural category in the land use/land cover file. Because agriculture was believed to be a significant pollutant source and because type of agricultural activity and use of agricultural BMPs had major bearing on pollutant estimates, agricultural activity was further disaggregated in order to develop more precise estimates of pollutant generation.

After the GIS data files were used to analyze nonpoint source pollutant generation, a separate reservoir water quality model (WQRRS) was used to evaluate existing and future water quality conditions in the Green Lane Reservoir. This modeling provided a better understanding of the eutrophication dynamics occurring in the waterbody and the net improvement expected to result from various management actions.

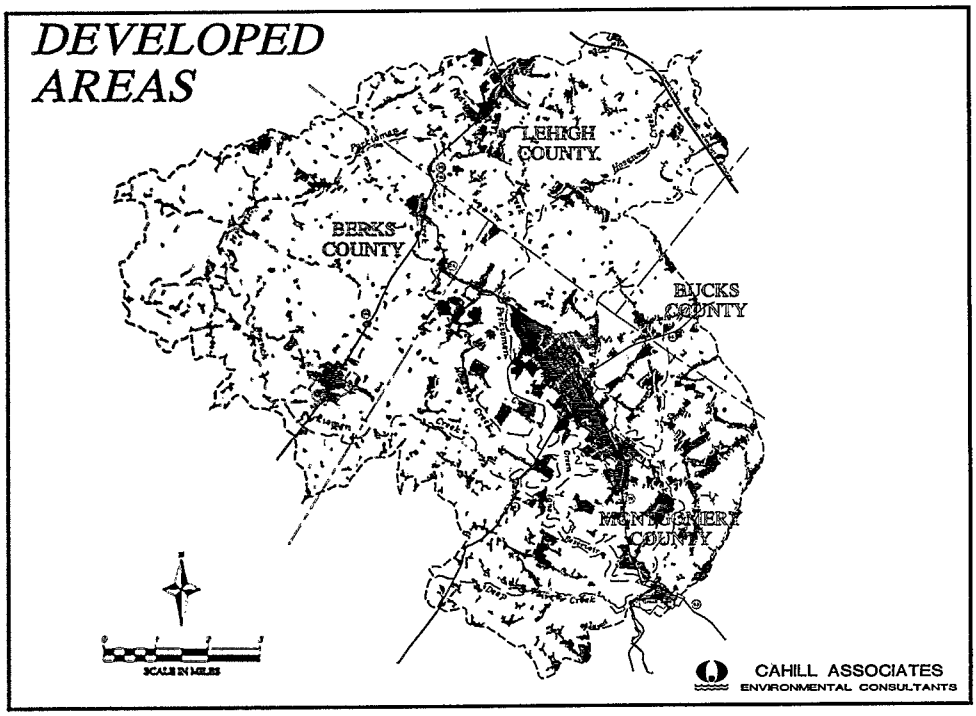

Figure 7. Upper Perkiomen Creek Watershed developed areas.

GIS Use in Watershed Management

The GIS in the Upper Perkiomen Project provided the basis for evaluations which were, in turn, used to formulate recommended management actions necessary to reduce existing pollutant sources and prevent additional pollutant loadings in the future. Special emphasis has been placed on broader-scale preventive actions—*nonstructural techniques*—which encompass total community planning efforts and on other programs which intervene in the development process *before* specific sites have been developed and lots have been subdivided.

Causal linkage was established first between existing levels of eutrophication in the waterbodies and existing nonpoint sources. The technical analysis indicated that agricultural nonpoint sources were especially large pollutant contributors. Based on these technically established causal linkages, management actions were identified to reduce nonpoint source pollutant loadings. Management in this case was area-wide in scope, targeted at agricultural activities throughout the Upper Perkiomen Watershed, although recommendations also were made for other pollution sources, such as malfunctioning on-site septic systems. Because of the capabilities of the GIS, different management options could be "tested out" in terms of their pollutant reduction capabilities/levels of effectiveness. Costs also could be tested. Such testing facilitated fine-tuning of the management program, so that recommendations could be identified which had the maximum "bang for the buck"—and maximum beneficial effect on the reservoirs. Management recommendations were communicated to the complicated array of state, county, municipal, public, and private agencies for implementation.

More importantly, analysis of *future* land uses indicated that substantial amounts of development would undo any pollutant reduction progress made on the existing sources, worsening reservoir eutrophication significantly in the future, *unless special management actions were taken.* A variety of management options—choices—presented themselves. For example, a certain percentage of nonpoint source pollutant loadings projected from new residential subdivisions at existing zoning densities could be controlled on a micro site-by-site basis through use of structural BMPs for storm water management, such as various types of infiltration techniques. Using a different and far more macro or areawide approach, these same "baseline" loadings could be reduced and managed through, for example, improved comprehensive planning in the watershed. Using the macro approach, attention could be given to how much growth should occur within this watershed, in contrast to other watersheds in the region. Regional determinations, including construction of new highway segments which involved regional planning commissions and the state highway department, were especially important factors on this macro level. This issue was also relevant because in the case of the Upper Perkiomen Watershed, so much of the watershed consisted of *portions* of municipalities, such that municipalities could opt to encourage development *outside* of watershed areas and discourage development *within* the watershed. Once a total growth strategy or level of growth was determined and growth was geographically distributed, the manner in which this growth occurred—its density—could be varied as well. Many different options—choices—were available—far more than most participants initially had realized. Clearly from a water quality perspective, configurations which concentrated development and minimized ultimate disturbance of the land surface yielded substantially reduced nonpoint source pollutant loadings into the reservoirs.

Testing different land use implications of different nonstructural management approaches for their water quality impacts indicated that pollutant loads could be minimized far more cost-effectively through management actions which started from the top down—from the macro to the micro. In sum, this demonstration of water quality problems resulting from future land development enabled by the GIS supported the case that watershed management actions should be as area-wide in nature as possible. Truly effective watershed management means intervention at the broadest possible level.

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Use of GIS Mapping Techniques to Inventory Potential Habitat Restoration Sites in a Highly Industrialized Urban Estuary

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The Puyallup River Estuary and Commencement Bay, the adjoining deep water embayment, are located at the southern end of Puget Sound's main basin. Prior to urban and industrial development in the late 1800s, the south end of Commencement Bay consisted primarily of mudflats and emergent marsh formed by the Puyallup River delta (Figure 1). Beginning in the 1870s industrial and port development caused tidal areas to be covered, the meandering Puyallup River straightened and diked, and industrial and port operations were built on filled areas of the delta. Extensive subtidal waterways have been dredged into the former intertidal mudflats and widespread sediment contamination further impairs nearshore habitats. As a result, it is one of the most disturbed estuaries in the Pacific northwest. This paper discusses an approach for collecting information on cumulative impacts using a data base and automated geographic information system (GIS) mapping system to interpret habitat losses to the Commencement Bay-Puyallup River estuary. Areas that could potentially be restored to function as aquatic habitats are mapped and evaluated. Recommendations for further steps needed to implement an estuary wide mitigation and restoration plan are discussed.

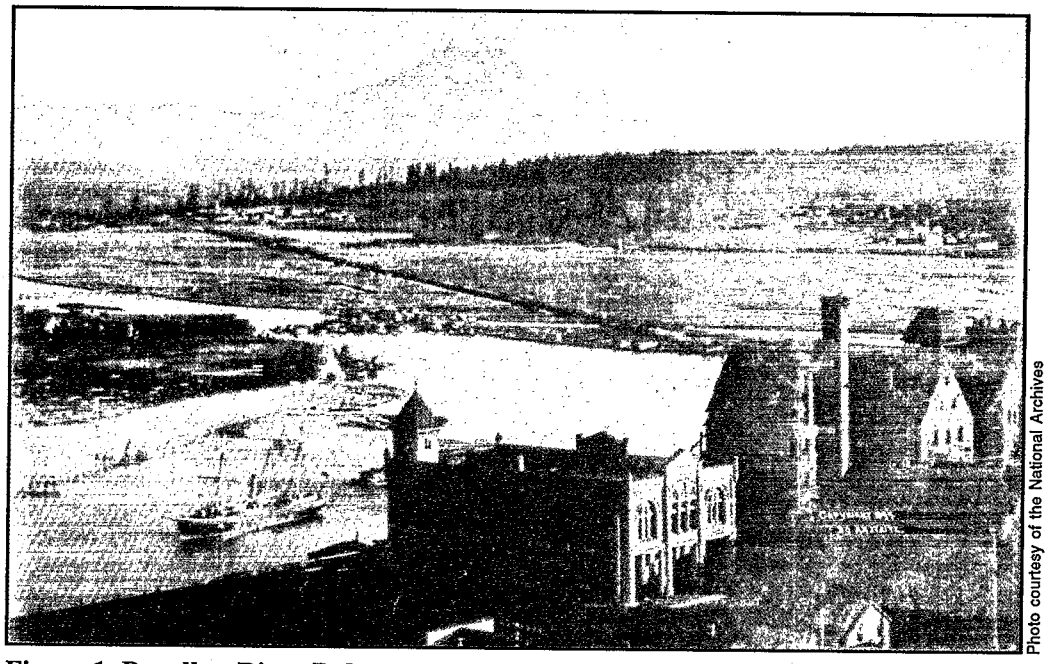

Photo courtesy of the National Archives

Figure 1. Puyallup River Delta and the town of Tacoma ca. 1894.

In 1990 the four federal agencies principally responsible with stewardship and regulation of coastal areas, the U.S. Army Corps of Engineers (COE), the U.S. Environmental Protection Agency (EPA), the U.S. Fish and Wildlife Service, and the National Oceanic and Atmospheric Administration (NOAA), jointly supported a study to document the cumulative impacts to the estuary and to evaluate the potential for habitat restoration. David Evans and Associates of Bellevue, WA, conducted a review of literature and archives to define historic changes in the marshes, mudflats, and eelgrass beds in the estuary. The EPA Environmental Monitoring Systems Laboratory, Las Vegas, NV, conducted a similar evaluation using historical aerial photos. Shapiro and Associates, Inc. conducted an inventory of potential restoration areas.

One of the first components of inventorying potential restoration areas was to document and map changes in estuarine habitats in the Puyallup delta to as early a date as possible. The term "restoration," as applied to this study, was defined as returning an estuarine habitat from a condition altered by some human action, to a previously existing natural or less altered condition. Therefore, the previous existing conditions need to be known. The likelihood of success for habitat restoration is high if historic processes still exist, e.g., hydrology, sedimentation, connections to other aquatic or upland habitats. Also, we presumed that the historical habitat composition of the estuary is the default template for initial steps in planning restoration projects.

For this study estuarine habitats were defined as changes to wetland marshes (estuarine or palustrine emergent marshes); mudflats (broad flat intertidal areas along the coast and in coastal rivers to the head of tidal influence); and vegetated shallows (eelgrass beds).

Methods

Historical Changes to Estuarine Habitats

To document changes in the Puyallup delta a literature, map, and photographic search was conducted to locate information on habitat types, waterfront development, and industry evolution. The data collected ranged from about 1850 to date. The literature search included the National Archives, university and museum collections, the state historical society, the Puyallup Indian Tribe, the COE regulatory files, survey records, maps, and newspapers. Beginning with 1941, COE aerial stereo-pair photographs were used to assess remaining habitats.

The project data and displays were created using an automated GIS computer software to automate, manipulate, analyze displays and store geographic data. Geographic data was organized using a relational data base system to store information about the mapped features. A graphic manipulation package was used to spatially analyze and display the mapped data. Geographical data may be input by digitizing, scanning, using coordinate geometry, or converting from other digitizing formats. The primary map data input method for this study was digitizing using the Universal Transverse Mercator (UTM) coordinate system. The data base was developed from a variety of historical materials depicting shorelines, hydrography, and roads. Maps that were well annotated with latitude/longitude or UTM values could be readily digitized. Digitizing uncontrolled map sources (i.e., without annotated coordinate control points) was more complicated. They were set up for digitizing by locating common points (e.g., section corners or pier corners) with the controlled maps, and deriving UTM values from these points. These points were then used to initialize the digitizing for the uncontrolled maps. Analyses included calculations of wetland and fill areas, and coastline changes. After developing the data base, a series of plots was created with areas shaded to show changes in land cover and use over time. By changing the manner of display, different changes may be evaluated. The advantages of comparing these relatively simple changes form the main basis for using GIS on this project (DEA, 1991).

Inventory of Potential Restoration Sites

The process of identifying restoration options and identifying candidate sites began with some preliminary restoration goal setting and identifying potential restoration techniques. Agency and tribal representatives began with a workshop to set restoration goals for the project. Nine institutional and functional goals were set. Institutional goals were to take an ecosystem

approach to restoration, to comprehensively plan for resource protection, and to involve the public in planning and carrying out restoration. Functional goals were to restore nearshore wetlands (mudflats, vegetated shallows, and salt marshes); restore freshwater emergent marsh; enhance and protect existing habitats; control sources and remediate contaminated areas; restore more natural riverine systems to the lower Puyallup; and to include innovative restoration options.

Restoration techniques that had been proposed or used in West coast estuaries were reviewed for use in Commencement Bay. Five general approaches were considered; substrate manipulations, shoreline alterations, planting, dike breaching, and artificial reefs. This review was followed by a general evaluation of land use, zoning, development plans, and acquisition and easement options along the lower watershed. General criteria for identifying and ranking candidate restoration sites were defined: size, current and historical use, contiguity, existing habitat, shoreline edge, elevation, and adjacent uses. Sites were considered for potential restoration if they were vacant, underdeveloped, or abandoned river or shorefront parcels. Unoccupied sites without structures were defined as vacant; sites with minor structures, but predominately vacant, were defined as underdeveloped; sites with structures not currently in use were defined as abandoned and considered possibly available for restoration. The approach for identifying, evaluating, and ranking potential restoration sites was to first use aerial photographs of the lower Puyallup River and Commencement Bay to locate areas. Potential sites were then visited on foot or by boat. Information was collected on ownership, value, land zoning and use, history, chemical contamination, and institutional constraints on habitat restoration at the site. Locations and approximate boundaries were delineated on a base map and digitized as a GIS data layer. Historical land use and chemical contamination information were collected from Superfund investigations (USEPA, 1989). Each potential site was given a priority ranking of high, medium, or low based on the size of the site, chemical contamination, existing and surrounding land uses, institutional constraints, existing habitat, potential for restoration, creation, or enhancement of habitat functions, and consistency with restoration goals (Shapiro, 1992).

Findings

Historical Changes to Estuarine Habitats

About 10 percent of the mudflats, marshes, and vegetated shallows existing in 1877 remain (Table 1). The emergent marsh occurred in a broad band between mean higher high-water level and upland forests, near the present location of Interstate 5 (Figure 2). Many of the marshes and mudflats that are present now are not original, but were formed after the original habitat was lost (DEA, 1991). Vegetated shallows are believed to historically have been scarce in this estuary due to the high sediment loading from the Puyallup River. However, historical information on eelgrass in the area is not available (Thom and Hallum, 1990). The lower Puyallup River historically meandered through a broad floodplain. In 1911 the White River was diverted from the Duwamish basin to the North into the Puyallup River and Commencement Bay, greatly increasing the Puyallup's drainage area (Blomberg et al., 1988). Diversion and channeling completely altered its deltaic, riparian character. Concrete and rock lined levees constrain the flow of the river. Trees, woody debris, and shrubs are routinely removed from the banks of the levees from the mouth for about 20 km upstream. Remaining wetlands along the lower river corridor such as old oxbows are isolated from the river. (DEA, 1992).

Inventory of Potential Restoration Sites

Forty-three parcels that could be suitable restoration sites were identified. For each site an estimate was made of the existing ecological functions and previous functions that could be restored. A general conceptual design was made for each restoration site (e.g., a dike breach, fill excavation, planting, shoreline or substrate

Table 1. Estimated changes in mudflat and emergent marsh areas from 1877 to 1988 (hectares)

Estuarine Habitat Type	Habitat Area in 1877	Habitat Area in 1988	Percent Change
Mudflat	839	76	- 91
Marsh	1,568	23	- 99
Vegetated shallows	Unknown	37	N/A

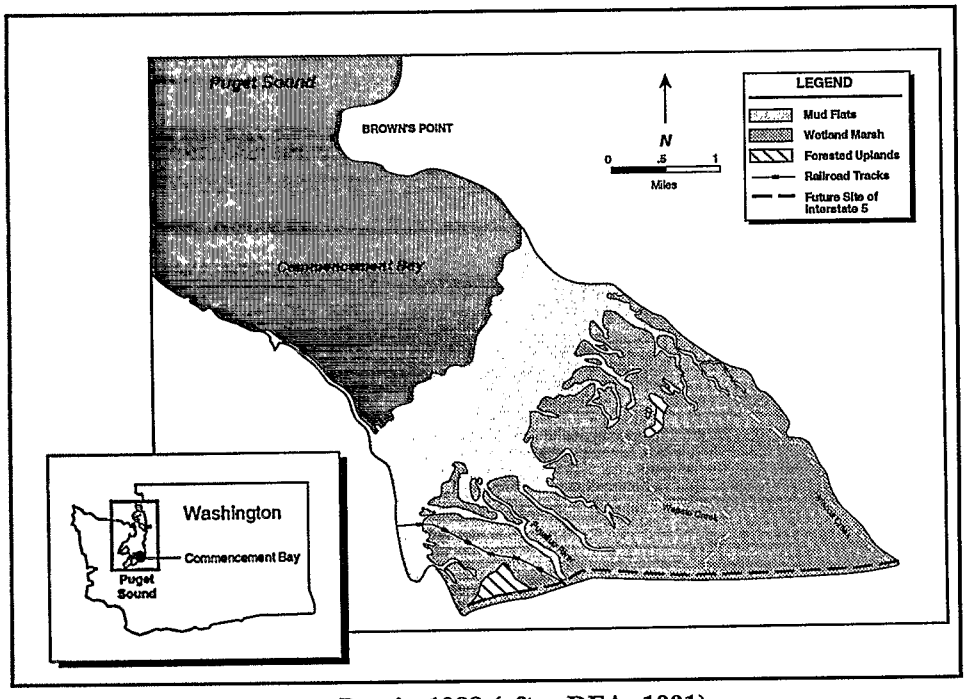

Figure 2. Commencement Bay in 1988 (after DEA, 1991).

modification), upon which cost estimates were based. Cost and complexity of restoration vary greatly depending on the extent to which the original hydrology, soils, and biotic communities were altered. General cost estimates were also made for restoration projects: construction, maintenance, and monitoring.

Uplands that were considered priority wildlife habitats by the Washington Department of Wildlife have been mapped. These areas, which included riparian zones, forested areas, bluffs, and urban natural open space, were digitized and added to the GIS data base. Chemical contamination locations had been digitized in the GIS as part of EPA's Superfund investigations in Commencement Bay. Outfall locations for storm water runoff, combined sewer overflows, sewage plants, industrial discharges, and contaminated sediment areas were also plotted as an overlay on the GIS map of potential restoration sites.

Discussion

Developing a GIS data base has been an extremely useful tool to compile and interpret information on the cumulative effects of many minor disturbances to the estuary and for initial restoration planning. Comparisons of historical and existing estuarine habitats, locations of potentially available parcels, and buffers for upland habitats and contamination threats were much more accessible with the GIS approach of superimposing layers. Evaluating these data sets were valuable first steps in our restoration planning. The GIS display approach was also valuable for identifying limitations in our approach and gaps in our understanding of the physical and ecological dynamics of the estuary. For high likelihood of success in estuarine habitat restoration, a large number of factors need to be considered in the design: migration corridors, circulation, salinity, freshwater discharge, turbidity and sedimentation patterns, water and sediment quality, and habitat attributes identified as being functionally important for target fish and wildlife species (Simenstad et al., 1991; Kusler and Kentula, 1990). Some of these factors lent themselves well to GIS, e.g., migration corridors, some habitat attributes, sediment contamination, and water pollution point sources. Others were either more dynamic, more poorly understood, or both.

Examples of important habitat attributes of which we need better understanding are the feeding and refuge functions for juvenile salmon. Downstream migrating juveniles of all Pacific salmon species use the estuarine habitats of their natal streams. In less disturbed estuaries, juveniles may spend either extended periods rearing, or, varying with the species, briefly use the estuary for acclimatization to higher salinity (Healey, 1982; Thom, 1987). Juvenile salmon still use the Commencement Bay nearshore extensively, feeding along the riprap waterways and in the water column, and using the underpiers and shore for refuge (Duker et al., 1989, Ratte, 1985). However, prey resources are limited by the removal of shallow flats, marshes, and quiet estuarine channels due to dredging and channelization. It is hypothesized that the juvenile salmon spend less time in the

disturbed estuary, moving on to open water when they are smaller; there they are considered more susceptible to predation (Simenstad et al., 1982, 1993). The only emergent marsh habitat available in the estuary is in a restored four hectare wetland in which juvenile salmon have been shown to forage and grow during their temporary residence (Shreffler et al., 1990, 1992). We would liked to have included in the GIS data base an overlay with critical areas identified for these functions, and criteria for siting enhancement and restoration projects. However, basic life history questions prevented us from attempting a template, even though juvenile salmonid's use of estuaries has received considerable study. For example, is there a functional threshold for habitat scale? Is the configuration of the component microhabitats critical? Would many scattered patches of marsh habitat function better than one large patch? Is there an upper threshold distance between patches? What are the requirements for migratory corridors and habitat transition buffers for fish and wildlife access to the habitat?

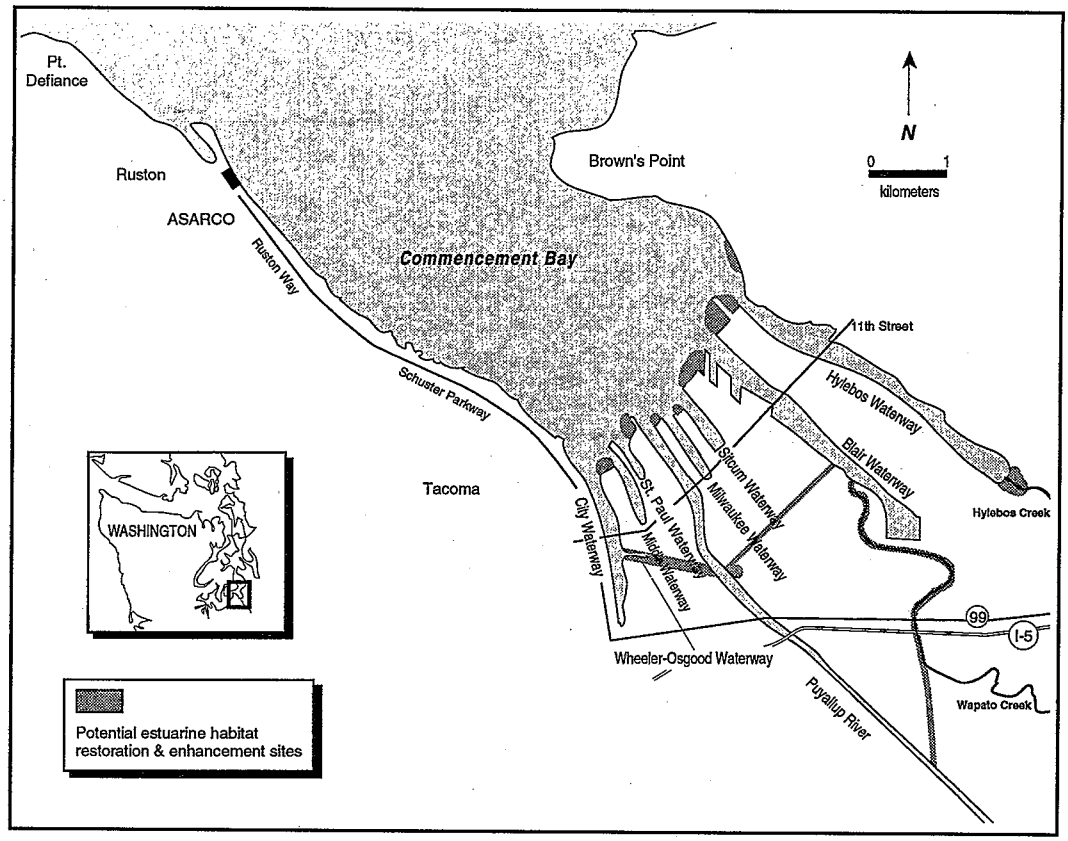

Figure 3. Potential aquatic restoration areas superimposed over existing special aquatic sites, upland habitat areas, and aquatic contamination problem locations.

The approach used here to identify the 43 relatively undeveloped shorefront parcels was adapted by Simenstad et al. (1993) to emphasize habitat benefits to benthic and epibenthic communities and to their consumer organisms (e.g., shorebirds, juvenile salmon, flatfish). Using some of the considerations listed earlier and several alternatives, they proposed four habitat types for restoration emphasis based on their position in the estuary and habitat types. The four habitat types identified for restoration and enhancement on this basis were low gradient mudflats, deltaic tidal channels, emergent brackish marshes, and eelgrass (Figure 3). For example, vestiges of the historic delta mudflats exist off the peninsulas between the fill peninsulas within the sediment laden river plume. One such intertidal flat was constructed in 1988 to cap highly contaminated sediments from a kraft pulp mill next to the mouth of the Puyallup. Monitoring results suggest the project has been successful thus far with rapid colonization by epibenthic and benthic organisms, functional habitat attributes, and presence of shorebirds and juvenile salmon (Weitkamp et al. 1991). A second intertidal flats project is planned for the opposite side of the river to mitigate further filling of the estuary. This will result in a large (by current standards) contiguous intertidal sand and mudflat at the mouth of the river. Likewise, certain drainage channels could be connected to the river, restoring some function of the former deltaic tidal creeks.

We compared the maps of potential restoration sites based on their vacancy, abandonment, or underdevelopment and, additionally, based on their position in the estuary and habitat types for food chain

support determined areas of overlap (Figure 3). We believe that this combined approach of methodically identifying, screening, and mapping potentially available parcels with the recommendations of estuarine ecologists who are familiar with the system was one of the strengths of this project. We expect that potential sites that were identified through both approaches will be further considered for restoration.

Developing a GIS data base has been an extremely useful tool to compile and interpret information on the recent ecological history of the estuary and for initial restoration planning. The GIS approach has also been a helpful aid to identify further information needed to develop a comprehensive bay-wide restoration and management plan.

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Data Base Development for the Coeur d'Alene Basin Restoration Initiative

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The purpose of this paper is to describe the development of an integrated data base containing digital environmental and spatial data for the Coeur d'Alene River basin in Northern Idaho. This data base and its associated retrieval engine will help support the restoration initiative currently underway by U.S. Environmental Protection Agency (EPA) Region X and the State of Idaho Division of Environmental Quality. The advantage of this system is that it provides these agencies with a single system that manages, accesses, and displays the environmental data collected for the basin.

Water quality in the Coeur d'Alene River basin has been seriously degraded due to the long-term (over 100 years) activities of mining, milling, and smelting operations in this region (Savage, 1986). In particular, the Bunker Hill mining and smelting complex—a designated EPA CERCLA (Superfund) site—is responsible for local environmental and health problems as well as being the origin of hazardous materials (i.e., heavy metals such as lead, zinc, and cadmium) that have become distributed throughout the basin.

A large number of environmental studies have been carried out in this region with respect to the effects of the mining operations on surface and ground water quality, air quality, aquatic and terrestrial biota, and human health. These studies are listed and summarized in Wai et al. (1985) and Savage (1986). Some of the information collected in these studies has been incorporated into electronic data bases that can be accessed directly by the EPA or other federal agencies. Still other data—not resident within a data base management system—are available on electronic media. Finally, a large body of data is only available in hard copy form.

Given this diversity of information, our initial focus was to examine and integrate all the EPA digital water quality and related spatial/environmental data bases that pertained to five cataloging units in Northern Idaho as listed below:

Cataloging Unit Number	Name
17010301	Upper Coeur d'Alene River
17010302	South Fork Coeur d'Alene River
17010303	Coeur d'Alene Lake
17010304	St. Joe River
17010305	Upper Spokane River

Figure 1 shows the location of these cataloging units in the Northern Idaho region. Having established this focus on electronic data bases pertaining to the cataloging units listed above, the remaining sections of this paper will describe the methodology used to build the integrated data base and the associated retrieval engine, and examples of the retrieval engine's capabilities.

Methodology

Data Inventory

Digital water quality data bases, resident on the EPA ES9000 mainframe

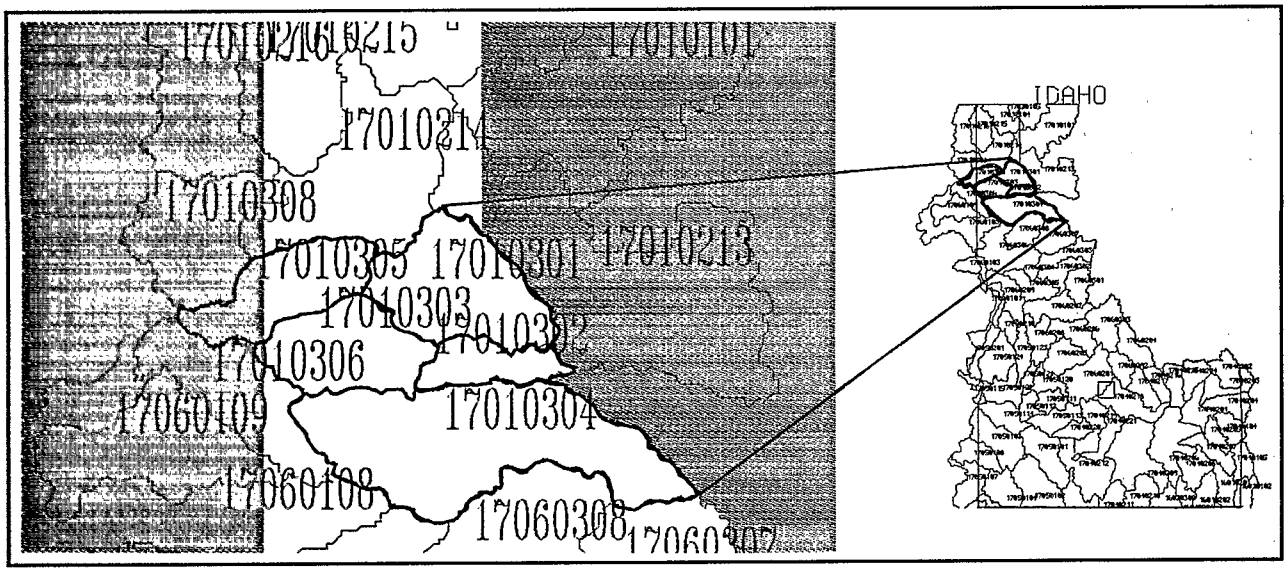

Figure 1. Map showing the location of the five cataloging units in Northern Idaho comprising the Coeur d'Alene Basin.

computer located in Research Triangle Park, NC, were inventoried to determine their data content relative to the five cataloging units comprising the Coeur d'Alene Basin. The data bases accessed included:

- Reach File (versions RF1, RF2, RF3).
- STORET water quality file.
- BIOS.
- Daily Flow File.
- Office of Water In-House Software (IHS) files—Gage, City, Dam, Drinking Water Supply, Industrial Facilities Discharge.
- Federal Reporting Data System (FRDS).
- Permits Compliance System (PCS).
- Toxic Chemical Release Inventory (TRI).
- Facility Index System (FINDS).
- Facility and Company Tracking System (FACTS).
- Waterbody System.

In addition to the above-mentioned data bases, several EPA data systems that access water quality and related environmental/spatial data were investigated. These included the Water Quality Analysis System (WQAS), particularly procedures such as the PCS-STORET Interface (IPS5), Mapping and Data Display Manager (MDDM), Environmental Display Manager (EDDM), and Reach Pollutant Assessment (RPA3), RF3 Master Selection System (RF3MSTR), and the Geographic Resources Information and Data System (GRIDS).

A detailed accounting of the results of these investigations and the data element lists for these data bases are contained in a data base inventory report submitted to EPA (SAIC, 1992a). In the following paragraphs, summary level descriptions of the results of this inventory are presented.

Reach structure (hydrologic linkages) and reach trace (latitude/longitude coordinates) information exists for both RF1 and RF2 in this region. To date, RF3 has not been completed for this region; however, the trace information is available through either RF3MSTR or MDDM. RF3 traces consist of the hydrography layer of the U.S. Geological Survey (USGS) 1:100,000 scale Digital Line Graph data. Figure 2 shows an example of these data for cataloging unit 17010303 (Coeur d'Alene Lake). RF1 and RF2 contain 298 and 386 segments respectively. Each segment has a set of geographic coordinates describing its trace and up to 78 data elements (see Table 1) describing its hydrologic characteristics (i.e., upstream/downstream linkages, length, etc.).

The STORET water quality file contained over 400,000 observations for 1,284 stations in the study area (1960 to present). BIOS contained 22 stations covering 160 sampling events. The Daily Flow File contained over 100,000 daily flow values measured at 35 USGS gaging stations with some data ranging as far back as 1911. These files all contain station

descriptive and locational data as well as the sample values. Files that provide ancillary descriptive data to STORET, BIOS, and the Daily Flow File, respectively, include the STORET parameter file, the BIOS taxonomic file, and the Gage file.

The Gage, City, Dam, Drinking Water Supply, and Industrial Facilities Discharge (IFD) files contain descriptive, locational, and reach index data for USGS gaging stations, dams, populated places, public water supplies, and permitted industrial/ municipal dischargers. The reach number is the common data element in these files. Thus, the data can be linked hydrologically and reach-based queries can be performed efficiently. Identification numbers in these files such as USGS gage IDs, NPDES numbers, and FRDS IDs allow a direct link to the Daily Flow File, PCS, or the Federal Reporting Data System. These files contained data for 20 USGS gages, 19 cities, 25 dams, 73 public water supplies, and 49 permitted dischargers in the study area.

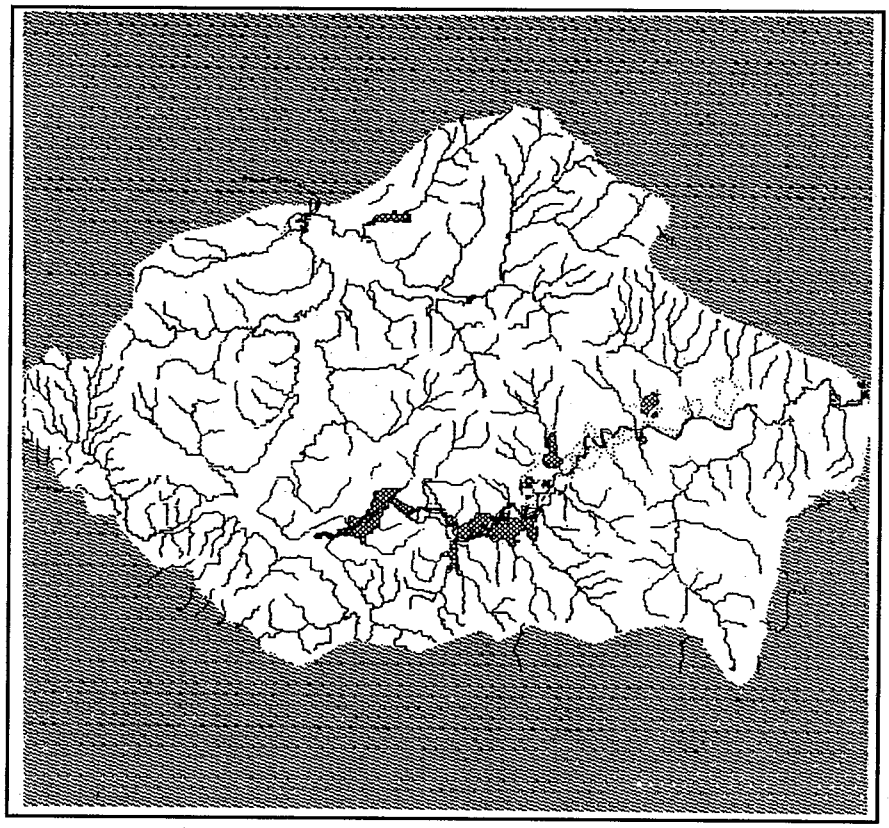

Figure 2. Digital line graph hydrography layer for cataloging unit 17010303 (Coeur d'Alene Lake).

The FRDS data base contained descriptive, locational, and enforcement data for over 400 public water supplies (both surface and ground water) in the study area. The PCS database contained permit limits and discharge monitoring reports for 22 of the 49 dischargers identified in the IFD file. The TRI data base contained less than 10 facilities for reporting years 1987-1990 with all releases being to air. FINDs reported 186 facilities monitored by one or more EPA data bases while FACTS reported on 4,175 facilities contained in the 1991 Dun and Bradstreet data base. The Waterbody system yielded no data in Idaho for the five cataloging units.

Additional environmental, spatial, and geographic data bases are also available for this region through EPA's GRIDS system. These data bases include the USGS Digital Line Graph 1:100,000 scale hydrography and transportation layers, USGS state and county boundaries, hydrologic unit boundaries, Geographic Data Technology 5 digit ZIP code boundary file, Census Bureau Master Area Reference File and Summary Tape File 3a, Census Bureau P.L. 94-171 population data, Donnelly Marketing population estimates, Census Bureau TIGER/Line Files, Defense Mapping Agency 3 arc second digital elevation model, and EPA ecoregion boundaries.

As a result of the Remedial Investigation/Feasibility Study (RI/FS) performed for the Bunker Hill Superfund site, water quality (ground and surface) data have been collected and spatial data (ARC/INFO) coverages have been developed by various EPA contractors. The surface water quality data cover the period 1987-1988. The ground water data were collected from 1988 to 1990. ARC/INFO coverages for the 21-square-mile Bunker Hill tract include 10-foot contour data, roads and trails, surface water drainage, building outlines, power distribution systems, vegetation, slope, and soil types.

Data Extraction and Translation

After completion of the data inventory task, data extracts were prepared for each of the data bases identified. In some cases, new

Table 1. Data element list for the reach structure file (RF2)

File	Grp #	Group	Use	Type	Data Elmt Count	Key Len	Deno	Data Elmt Name	Key	Index	Type	Fixed Length	Dec Pos	Internal Length	Description	
RCHSTR	1	10001MAJ	A	S	1	0	1	CU	N	Y	A	8	0	8	CATALOGING UNIT	
RCHSTR	2	10001MIN	B	S	1	0	1	REACH	N	Y	A	10	0	10	CATALOG UNIT SECMENT MILEPT (PACKED (11) FL)	
RCHSTR	3	10002MAJ	A	S	1	0	1	CUNAME	N	Y	A	30	0	30	CU NAME	
RCHSTR	4	20001MIN	B	S	9	0	1	GUPINDX	N	Y	A	28	0	28	UPSTREAM INDEX (SNAU/SNAD FLAG-DIVCODE -)	01
							2	GUPINDX	N	Y	A	28	0	28	DOWNSTREAM "(CUSEGMI SEGL DSNAU/DASUM)	02
							3	GPMILE	N	N	F	6	0	4	PATH LENGTH (FLOAT)	03
							4	GJ	N	N	B	4	0	2	BINARY JUNCTION NO.	04
							5	GDCSM	N	Y	A	10	0	10	DOWN STREAM CUSEGMI (FD (11) FLOAT)	05
							6	GCCSM	N	Y	A	10	0	10	COMPLEMENT CUSEGMI (FD (11) FLOAT)	06
							7	GULCSM	N	Y	A	10	0	10	UPSTREAM LEFT CUSEGMI (FD (11) FLOAT)	07
							8	GURCSM	N	Y	A	10	0	10	UPSTREAM RIGHT CUSEGMI (FD (11) FLOAT)	08
							9	GCDNUP	N	Y	A	18	0	18	CUSEGMI SNAU (*) SNAD (*)	09
RCHSTR	5	20002MIN	B	S	66	0	1	CUSEGMI	N	Y	A	16	0	16	CU, SEG, MI (16.2-THE 5 MI BYTES BLANK IF AB)	01
							2	SEQNO	N	Y	A	11	0	11	SEQ NUMBER ASCENDING DOWNSTREAM (*)	02
							3	RFLAG	N	N	A	1	0	1	REACH FLAG (0, 1) 0=NOT PRESENT	03
							4	OWFLAG	N	N	A	1	0	1	OPEN WATER FLAG (0, 1) 0=NOT PRESENT	04
							5	TFLAG	N	N	A	1	0	1	TERMINAL FLAG (0, 1) 0=NOT PRESENT	05
							6	SFLAG	N	N	A	1	0	1	START FLAG (0, 1) 0=NOT PRESENT	06
							7	TYPE	N	Y	A	1	0	1	SEGMENT TYPE	07
							8	SEGL	N	N	A	5	0	5	5.1 SEGMENT LENGTH (MI.)	08
							9	LEV	N	N	A	2	0	2	LEVEL	09
							10	J	N	N	A	2	0	2	JUNCTION NUMBER	10
							11	K	N	Y	A	1	0	1	DIVERGENCE CODE	11
							12	PMILE	N	N	A	8	0	8	8.1 PATH MILE	12
							13	ARBSUM	N	Y	A	8	0	8	ARBOLATE SUM	13
							14	DSSEQ	N	N	A	11	0	11	DOWNSTREAM SEQNO	14
							15	USSEQ	N	N	A	11	0	11	UPSTREAM SEQNO	15
							16	USDIR	N	N	A	1	0	1	UPSTREAM REACH DIRECTION (L OR R)	16
							17	TERMID	N	Y	A	5	0	5	TERMINAL STREAM SYSTEM ID	17
							18	TRMBLV	N	N	A	1	0	1	TERMINAL BASE LEVEL	18
							19	STRTSQ	N	N	A	11	0	11	LEVEL START SEQNO	19
							20	STOPSQ	N	N	A	11	0	11	LEVEL STOP SEQ	20
							21	PNAME	N	Y	A	30	0	30	PRIMARY NAME	21
							22	PNMCD	N	Y	A	11	0	11	PRIMARY NAME CODE	22
							23	CNAME	N	N	A	30	0	30	COMPLEMENT NAME	23
							24	CNMCD	N	N	A	11	0	11	COMPLEMENT NAME CODE	24
							25	OWNAME	N	Y	A	30	0	30	OPEN WATER NAME	25
							26	OWNMCD	N	Y	A	11	0	11	OPEN WATER NAME CODE	26
							27	DSCSM	N	N	A	16	0	16	DOWNSTREAM CU, SEG, MILE POINT (16.2)	27
							28	CCSM	N	N	A	16	0	16	COMPLEMENT CU, SEG, MILE POINT (16.2)	28
							29	CDIR	N	N	A	1	0	1	COMPLEMENT BANK DIRECTION (L OR R)	29
							30	ULCSM	N	N	A	16	0	16	UPSTREAM LEFT CU, SEG, MILE POINT (16.2)	30
							31	URCSM	N	N	A	16	0	16	UPSTREAM RIGHT CU, SEG, MILE POINT (16.2)	31
							32	ULAT	N	N	A	8	0	8	8.4 UPSTREAM LATITUDE	32
							33	ULONG	N	N	A	8	0	8	8.4 UPSTREAM LONGITUDE	33
							34	Q3LAT	N	N	A	8	0	8	8.4 THIRD QUARTILE LATITUDE	34
							35	Q3LONG	N	N	A	8	0	8	8.4 THIRD QUARTILE LONGITUDE	35
							36	MDLAT	N	N	A	8	0	8	8.4 MIDPOINT LATITUDE	36
							37	MDLONG	N	N	A	8	0	8	8.4 MIDPOINT LONGITUDE	37
							38	Q1LAT	N	N	A	8	0	8	8.4 FIRST QUARTILE LATITUDE	38
							39	Q1LONG	N	N	A	8	0	8	8.4 FIRST QUARTILE LONGITUDE	39
							40	DLAT	N	N	A	8	0	8	8.4 DOWNSTREAM LATITUDE	40
							41	DLONG	N	N	A	8	0	8	8.4 DOWNSTREAM LONGITUDE	41
							42	MINLAT	N	N	A	8	0	8	8.4 MINIMUM LATITUDE	42
							43	MINLON	N	N	A	8	0	8	8.4 MINIMUM LONGITUDE	43
							44	MAXLAT	N	N	A	8	0	8	8.4 MAXIMUM LATITUDE	44
							45	MAXLON	N	N	A	8	0	8	8.4 MAXIMUM LONGITUDE	45
							46	TWLAT1	N	N	A	8	0	8	8.4 TUCKER WINDOW LAT/LONG PAIRS	46
							47	TWLNG1	N	N	A	8	0	8	8.4 TUCKER WINDOW LAT/LONG PAIRS	47
							48	TWLAT2	N	N	A	8	0	8	8.4 TUCKER WINDOW LAT/LONG PAIRS	48
							49	TWLNG2	N	N	A	8	0	8	8.4 TUCKER WINDOW LAT/LONG PAIRS	49
							50	TWLAT3	N	N	A	8	0	8	8.4 TUCKER WINDOW LAT/LONG PAIRS	50
							51	TWLNG3	N	N	A	8	0	8	8.4 TUCKER WINDOW LAT/LONG PAIRS	51
							52	TWLAT4	N	N	A	8	0	8	8.4 TUCKER WINDOW LAT/LONG PAIRS	52
							53	TWLNG4	N	N	A	8	0	8	8.4 TUCKER WINDOW LAT/LONG PAIRS	53
							54	NSTCO	N	N	A	1	0	1	NUMBER OF STATE/COUNTY CODES	54
							55	SCFLAG	N	N	A	1	0	1	STATE/COUNTY FLAG	55
							56	STC01	N	Y	A	5	0	5	STATE/COUNTY FIPS CODES	56
							57	STC02	N	Y	A	5	0	5	STATE/COUNTY FIPS CODES	57
							58	STC03	N	Y	A	5	0	5	STATE/COUNTY FIPS CODES	58
							59	STC04	N	Y	A	5	0	5	STATE/COUNTY FIPS CODES	59
							60	STC05	N	Y	A	5	0	5	STATE/COUNTY FIPS CODES	60
							61	STC06	N	Y	A	5	0	5	STATE/COUNTY FIPS CODES	61
							62	STC07	N	Y	A	5	0	5	STATE/COUNTY FIPS CODES	62
							63	STC08	N	Y	A	5	0	5	STATE/COUNTY FIPS CODES	63
							64	QC1	N	Y	A	1	0	1	QUALITY CONTROL CONDITION A-9	64
							65	QC2	N	Y	A	1	0	1	QUALITY CONTROL CONDITION A-9	65
							66	ZZZZZ	N	N	A	1	0	1	DUMMY (* SEQUENCE NUMBER ASCEND/DESCEND)	

software was developed to extract the necessary data elements (i.e., PCS and STORET); for other data bases (i.e., FRDS, IHS files), existing data extraction capabilities were employed (i.e., the use of EPA's General Query capability to build extracts of the IHS files). The extract files were then downloaded from the EPA mainframe computer and converted into dBASE (.dbf) files for use by the retrieval engine software. To date, the Reach File (RF2), STORET, BIOS, Daily Flow, Gage, Drinking Water Supply, City, Dam, Industrial Facilities Discharge (IFD), Federal Reporting Data System (FRDS), and Permits Compliance System (PCS) have been extracted and are accessible by the retrieval engine. The Facility Index System (FINDS), Toxic Chemical Release Inventory (TRI), Bunker Hill Water Quality data, and spatial data files (i.e., ARC/INFO coverages for the Bunker Hill Superfund site and miscellaneous boundary files) have been obtained but are not currently integrated into the system. The next stage of retrieval engine development will bring in these data sets. They are, however, currently available as separate data files in their native format.

Retrieval Engine Development

The design of the Coeur d'Alene Restoration Initiative Data System (CDRID) was based on organizing the data bases hydrologically by cataloging unit and/or reach number and providing access paths to the data that took advantage of this level of organization (SAIC, 1992b). After the data bases were extracted and downloaded from the EPA mainframe computer, they were converted to dBASE files (.dbf files) and the CDRID application software, written in CLIPPER, was developed. Figure 3 illustrates the CDRID opening screens showing the cataloging units available for selection and the associated, indexed data bases.

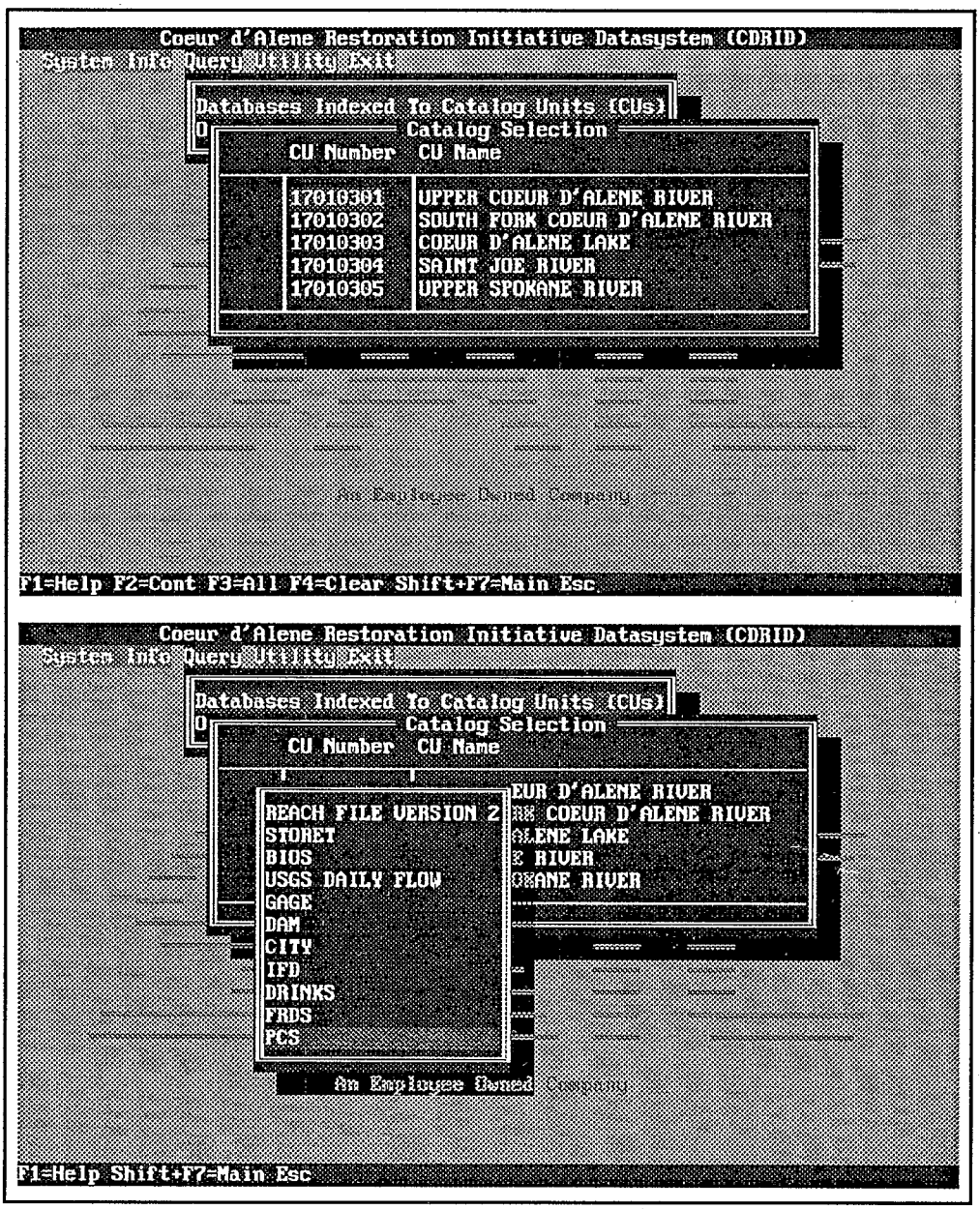

Figure 3. Coeur d'Alene Restoration Initiative Datasystem (CDRID) opening screens showing the selectable cataloging units and databases.

An example retrieval is illustrated in Figure 4. In this case, a portion of the reach structure file (for RF2) is examined for all reaches in the Upper Coeur d'Alene River (cataloging unit 17010301). The information displayed in this example includes the reach number, mile point, type, segment length, stream level, upstream direction, and reach name. The remaining reach structure information (not shown in Figure 4) can be viewed by scrolling to the right.

Another example retrieval is shown in Figure 5. This retrieval shows the display of a portion of a Discharge Monitoring Report (DMR) from PCS for the Bunker Hill Mining Company (NPDES number ID0000078). The information displayed includes the parameter number, name, and minimum monthly concentration of several water quality parameters. The remaining DMR data can be viewed by scrolling down or to the right.

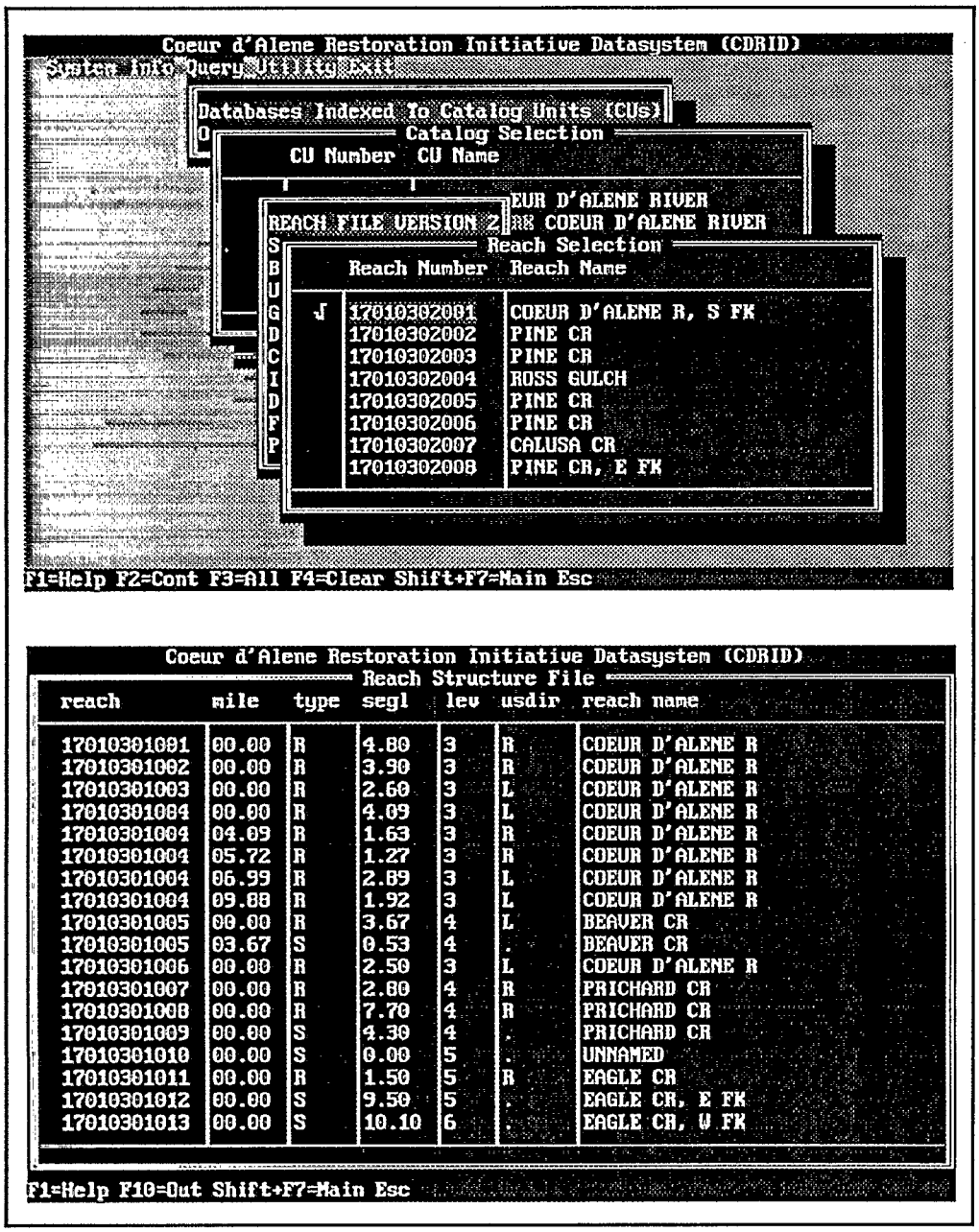

Figure 4. Example retrieval showing a portion of the reach structure file (RF2) for all reaches in the Upper Coeur d'Alene River (Cataloging unit 17010301).

Acknowledgments

This study was funded by the U.S. Environmental Protection Agency, Office of Wastewater Enforcement and Compliance—Contract Number 68-C8-0006 (WA C-334(P)) to Science Applications International Corporation. The authors wish to thank Jackie Romney, EPA work assignment manager, Don Martin, EPA Regional Technical contact, and Jim Parker, SAIC work assignment manager, for their guidance throughout the project. In addition, we wish to thank Rick Albright, EPA Region X; Geoff Harvey, Idaho Division of Environmental Quality; Ray Peterson, EPA Region X; and Matt Gubitosa, EPA Region X for their comments and suggestions on the design and implementation of the data

base and retrieval engine. Finally, we acknowledge the assistance of Craig Lukin, Carl Johnson, and Heip Mai of SAIC (Bothell, WA) for providing ARC/INFO coverages and water quality data related to the Bunker Hill Superfund site.

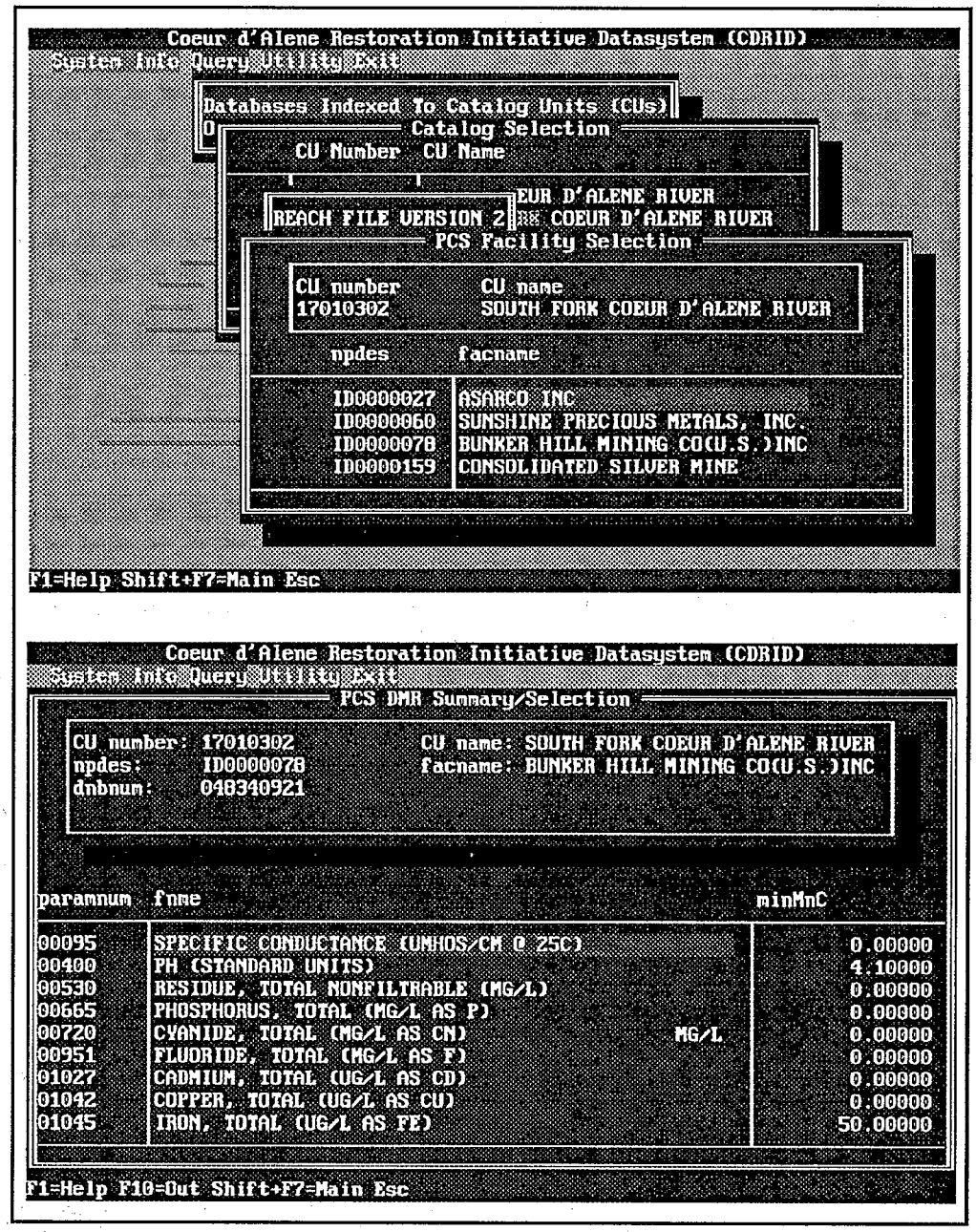

Figure 5. Example retrieval of a portion of the PCS Discharge Monitoring Report for the Bunker Hill Mining Company.

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Nonpoint Source Assessment and Accounting System NPS Management and Evaluation Tool

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The control of nonpoint source (NPS) pollution is a major water quality and resource concern for the State of Maryland. To better assess NPS pollution and improve NPS control programs, Maryland is developing the Nonpoint Source - Assessment and Accounting System (NPS-AAS). The NPS-AAS is a geographic information system (GIS)-based model designed to provide a consistent means of evaluating NPS nutrient pollution and the effectiveness of management alternatives. It will be used to provide cost-effective direction for state and local watershed management efforts and track and evaluate results. The Maryland Office of Planning (OP), under the direction of the State's Interagency NPS Steering Committee, coordinates the NPS-AAS.

The NPS-AAS is a planning tool which organizes data on water quality, management practices, and NPS research. These data are related to landscape characteristics in specific geographic areas using a GIS and a relational data base. The NPS-AAS estimates relative phosphorus and nitrogen loads generated from the landscape by source categories (defined by land use and soils) and terrestrial flow pathway (surface runoff, subsurface flow, and deep ground-water flow). This approach could be used in any watershed in which the required data have been compiled and properly applied to the landscape.

The NPS-AAS is being developed for statewide use, with first application in the Patuxent River Watershed (Figure 1). The Patuxent Watershed was selected as the prototype because of the extensive water quality, research and monitoring data, and modeling work available for developing the NPS- AAS. This paper will provide an overview of the NPS-AAS and illustrate application in the Patuxent Watershed.

Framework

The NPS-AAS directly links the effects of specific pollutant sources, landscape conditions, and management actions to nutrient loads through a relational data base. The NPS-AAS incorporates three major land based sources of pollution—on-site sewage

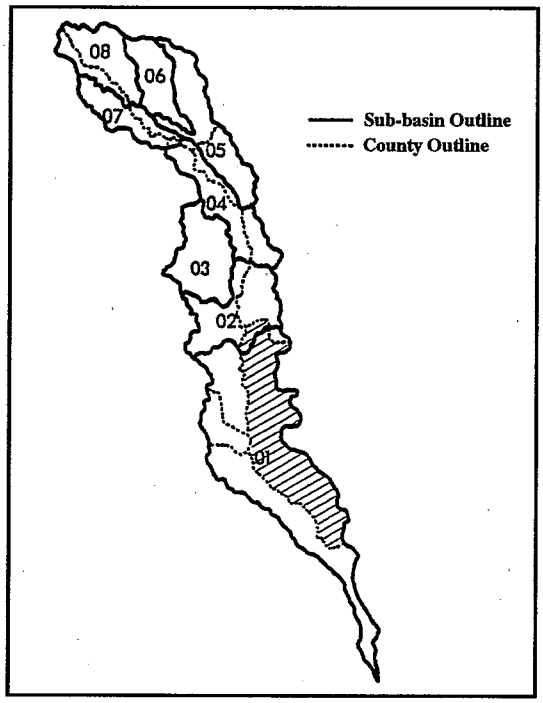

Figure 1. Patuxent River Watershed. Shaded area corresponds to data presented in Figures 3 and 4.

disposal systems (OSDS), land use, and animal concentration (Figure 2).

Land Use Component

The NPS-AAS estimates nutrient loads generated from the landscape by land use (Table 1). Data on land use, soils, streams, watershed and county boundaries, waterbodies, zoning, sewer service, and comprehensive plans are digitized and incorporated into OP's GIS. These data provide a consistent representation of watersheds across the state.

Soils are classified into Natural Soil Groups (NSGs) of Maryland (Maryland OP, 1973). Based on soil characteristics of permeability, runoff potential, water table, erodibility, and slope, the NSGs have been rated for their potential to export total nitrogen (TN) and total phosphorus (TP) (James Brown, State Soil Conservation Service, personal communication, 1992). Through the GIS, land uses on soils with low, moderate, or high potential to export TN or TP have been identified and the number of acres determined by county and watershed.

The relative TP and TN contributions from a given source category (land use and soil combination) are calculated using loading coefficients (kilogram hectare year) representing relative potentials to discharge TN and TP at the small watershed scale. The use of nutrient loading coefficients, although not as precise as loading functions and simulation models, provides a fast, easy method to estimate the average annual nutrient load released from the landscape. However, care must be taken in the selection of loading factors to ensure that they represent conditions characteristic of the study area.

The nutrient export coefficients used in the NPS-AAS were compiled from published and unpublished data and model results. To decrease uncertainty and improve reliability, only nutrient coefficients from locations with climatic conditions, land uses, and soils similar to Maryland were used. Coefficients were assembled into a distribution for each land

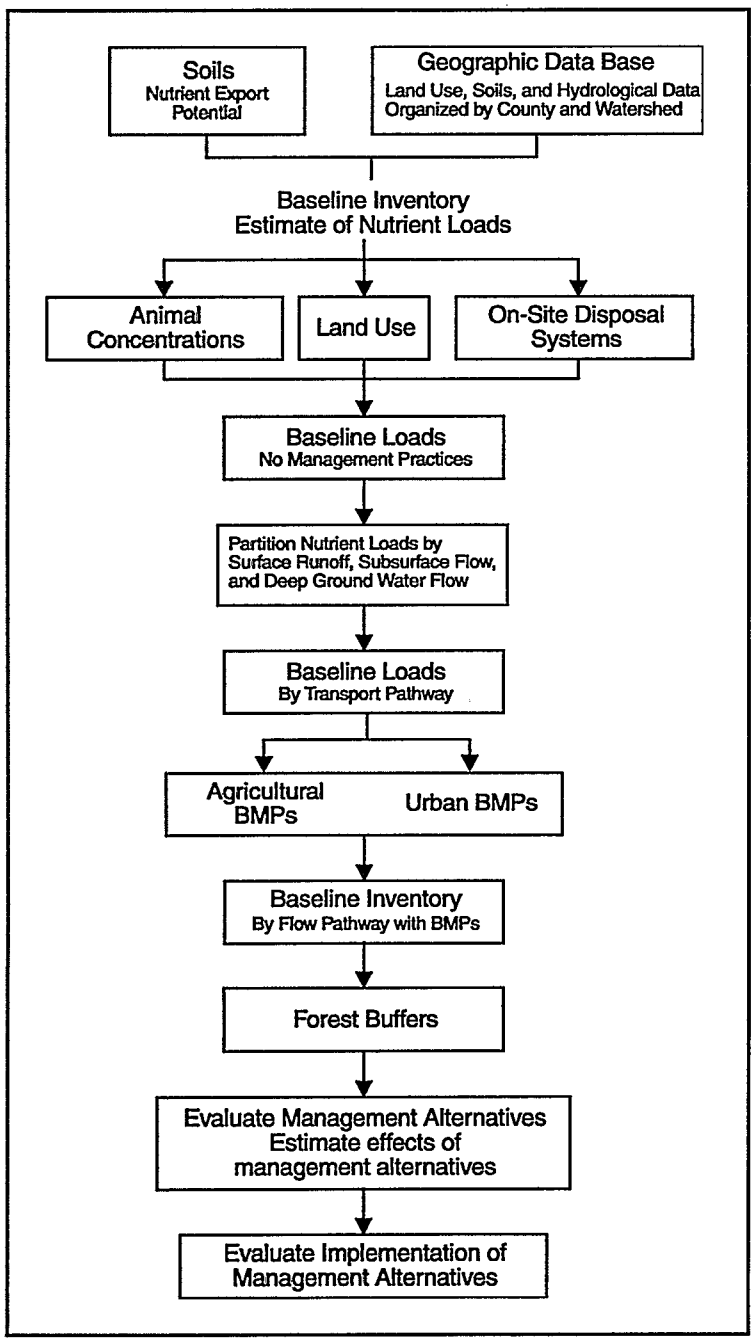

Figure 2. Major components of the Nonpoint Source - Assessment and Accounting System.

Table 1. Land use categories used on the NPS-AAS

- Rural Residential
- Low Density Residential
- Moderate Density Residential
- High Density Residential
- Commercial
- Industrial
- Cropland
- Pasture
- Forest
- Water
- Wetlands

use category to characterize the range of in-stream loading rates associated with each land use. The central one-third of each distribution is used to eliminate extreme values.

Based on results of research on the role of soils in nutrient export, loading coefficients from the distribution are assigned to a source category. Put simply, a soil with a higher export potential is assigned a higher coefficient than the same land use on a soil with a lower export potential.

Nutrient loads from the landscape are partitioned by flow pathway—surface runoff, shallow subsurface flow, and deep ground water flow using "partitioning factors" derived from the Chesapeake Bay Hydrologic Simulation Program—Fortran model. This information is important in estimating the reduction in nutrient loads which can be attributed to a given Best Management Practice (BMP).

On-Site Sewage Disposal Systems

OSDS can contribute significant levels of nitrogen to subsurface flow and ground water subsequently to surface water. The NPS-AAS uses the U.S. Environmental Protection Agency's estimate that approximately 65 percent of the nitrogen leaving the trench in a drainfield reaches subsurface waters. We assume that nitrogen from OSDS will experience additional reductions prior to reaching surface waters similar to reductions observed for nitrogen leaving agricultural lands (Reneau, 1977). The number of homes on OSDS is estimated by overlaying the land use and sewer service data in the GIS.

Animal Concentration

The nutrient contributions of animal production facilities in the Patuxent were estimated by determining the areal extent of animal feeding operations or waste storage (exposed to rainfall and runoff), applying the appropriate export coefficient, and adjusting loads to reflect percent of time annually spent in the feedlots. Information on 1990 animal population, percent time spent, and areal extent were obtained from the Maryland Department of Agriculture (MDA) and the soil conservation districts (SCDs) in the Patuxent.

Best Management Practices

Information on implementation of agricultural and urban BMPs was compiled through a coordinated effort by MDA, the Maryland Department of the Environment (MDE), OP, local agencies, and SCDs. BMP effects are calculated as a percent reduction in nutrient load by transport pathway.

An inventory and evaluation of data on implementation and status of agricultural BMPs was performed. The most consistent data base available on agricultural BMPs in the Patuxent is the use of State Soils Conservation Service's 901s which is a measure of the aggregated effect of soil conservation practices. It is expressed as tons of soil saved per year.

Data on management of storm water from developed land was compiled by MDE and the Patuxent counties.

Forest Buffers

Riparian forests can, under appropriate hydrological and physical conditions, reduce nutrients loads from adjacent land uses (Cooper, 1986; Schnabel, 1986). A riparian buffer component—that area within 100 feet of any stream—was incorporated into the NPS-AAS to account for these reductions. Soils with the greatest potential for contact between subsurface flow and the rooting zone with appropriate ecological characteristics (low oxidation potential, high water table, high moisture content, and high organic content) were identified through the soil and land use data in the GIS. These areas tend to have high rates of denitrification and plant uptake.

The percent of buffer in forest on appropriate soils is used to represent an "effective buffer ratio" (EBR). The EBR represents that portion of the buffer with greatest potential to reduce nutrient loads.

Surface runoff from land uses with a high percent of impervious surface was assumed to be channelized and bypass riparian zones buffers. Nutrient loads generated from agriculture, upland forests, and low-density developed land uses were assumed to be affected by the riparian buffer. Nutrient loads moving via surface runoff from low density development were also assumed to bypass forest buffers.

Output

The NPS-AAS has been applied in the Patuxent and a draft baseline inventory of existing conditions produced. The baseline inventory provides an estimate of relative nutrient loads by sub-watershed and county for specific land uses and soil combinations as well as by transport pathway.

Preliminary results for watershed 02-13-11-01 in Calvert County, MD, illustrate how output from the NSP-AAS can address land use and NPS management concerns (Figures 3 and 4). Agriculture, occupying 28 percent of the watershed, contributes approximately 45 percent of the phosphorus (Figure 3). Soil conservation BMPs are estimated to reduce the phosphorus load from agriculture by approximately 29 percent. Developed land contributes 28 percent of the phosphorus load. Urban storm water management is present on 7 percent of the developed land and consequently reduces associated phosphorus loads by only 2 percent. Forest buffers are estimated to have little effect on phosphorus loads from development, while reducing loads from agriculture and upland forest by an additional 9 percent and 7.5 percent (Figure 3).

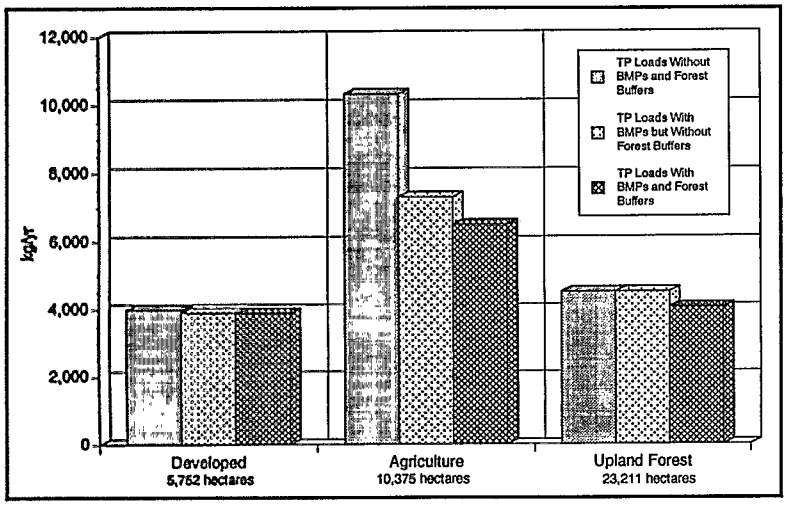

Figure 3. Relative contribution of phosphorus by major land use categories, Calvert County - Watershed 02-13-11-01, based on 1990 MD Office of Planning land use data.

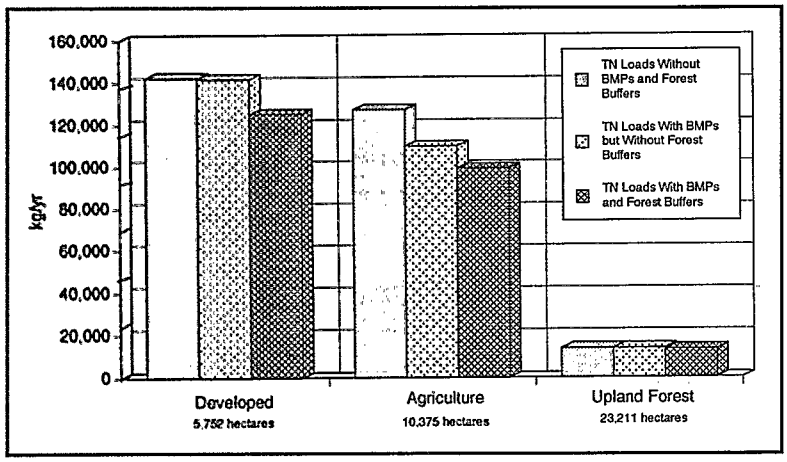

Figure 4. Relative contribution of nitrogen by major land use categories, Calvert County - Watershed 02-13-11-01, based on 1990 MD Office of Planning land use data.

Developed land is the major contributor of nitrogen (50 percent), reflecting a large nitrogen contribution from OSDS. It is estimated that 85 percent of the homes in this watershed are on OSDS. As with phosphorus, urban BMPs only reduce nitrogen by 3 percent reflecting the low level of urban BMP implementation. However, unlike the case for phosphorus, forest buffers (Figure 4) have a significant impact on the nitrogen loads generated from developed land.

Growth/management scenarios are currently being developed for the Patuxent and the NPS-AAS will be rerun for these scenarios. The relative change between baseline inventory loads and growth/management scenario loads will be used to identify the management alternatives to achieve pollution control objectives.

Examples of some of the basic questions the growth scenarios will be able to address, when completed include:

- What impact will alternative development patterns and strategies have on nutrient loads?
- What impact will clustering and Maryland's forest Conservation Act have on nutrient loads from future development?
- What are the relative benefits of nutrient management and cover crops on cropland?
- What are the benefits of confining new growth to areas with sewer service?

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Impact of Jurisdictional Conflict on Water Resource Management, Rosebud Indian Reservation, South Dakota

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Rosebud Sioux Indian Reservation is a federally recognized Indian tribe incorporated under the Act of June 18, 1934, 48 statute-984 (Rosebud Sioux Tribe (RST) Constitution, 1935). The Reservation is located in south central South Dakota (Figure 1). The original boundaries of the Reservation (Treaty of 1889) encompassed the counties of Todd, Mellette, Tripp, Lyman, and Gregory, an area of 3,710,400 acres. By a decision of the U.S. Supreme Court in 1970, the exterior boundary of the Reservation was reduced to just Todd County (Figure 2). However, the tribal government was allowed to exercise jurisdiction over tribal/trust lands in the other four counties.

The Indian population on the original Reservation is 11,737 and that in Todd County alone is 9,199. The non-Indian population is estimated to be 1,469 in Todd County.

For the purpose of this study, the focus will only be on Todd county or the existing Reservation, as declared by the U.S. Supreme Court. The Reservation covers 931,840 acres. It is 52 miles in length and 28 miles in width. The major towns include Rosebud, St. Francis, Parmelee, Mission/ Antelope, and Okreek (Figure 2). The town or city of Mission, the largest on the Reservation, is incorporated under the State of South Dakota. Therefore the City Council and the state claim that Mission does not fall under the jurisdiction of the Tribe. The Tribe on the other hand rejects this claim.

In terms of land ownership, the Reservation is a checkerboard of Indian lands and non-Indian lands. Sixty percent of the lands are owned by the Tribe or tribal members and 40 percent are fee lands owned by non-Indians.

The non-Indians within the Reservation do not acknowledge tribal authority over them and look to the State of South Dakota for it.

Hydrogeology of the Reservation

The northern tip of the Ogallala/High Plains Aquifer is on Rosebud Reservation (Figure 3). It extends from Texas in the south to South Dakota in the north. Ogallala and Arikaree Formations are lumped together under the High Plains Aquifer. The general water quality of the aquifer is good, although man-made activities reportedly are polluting the aquifer in a few places. The thickness of the aquifer ranges from less than 90 feet to greater than 190 feet.

Ogallala Formation comprises fine to medium grained sandstone and the Arikaree is siltstone. The potentiometric

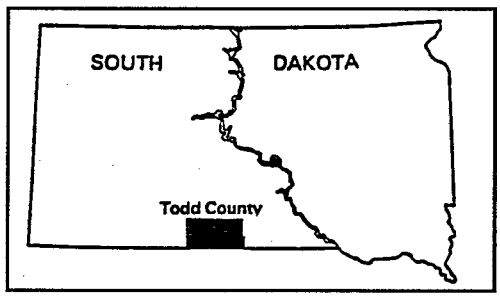

Figure 1. Location of Rosebud Reservation in South Dakota.

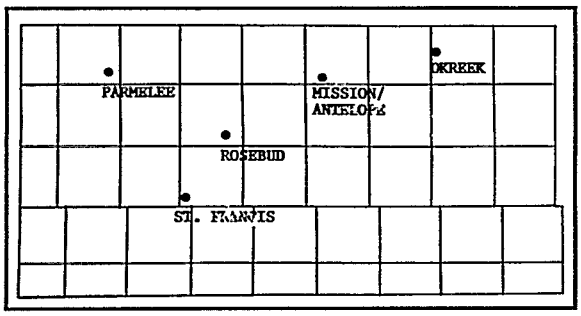

Figure 2. Todd County, South Dakota, showing the major towns.

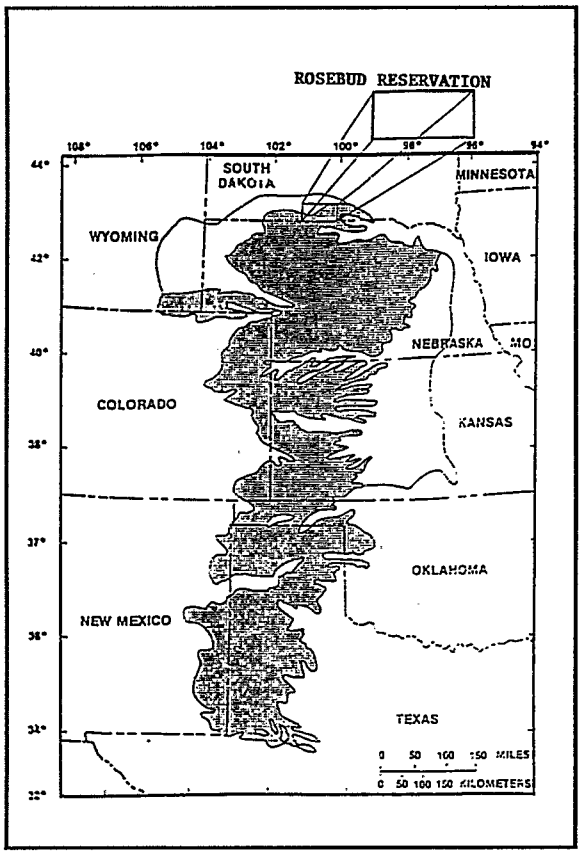

Figure 3. Extent of High Plains Aquifer up to Rosebud Reservation.

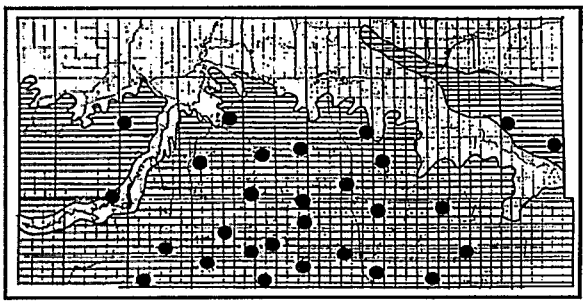

Figure 4. Monitoring wells network on the Aquifer. (Shading indicates the Aquifer.)

surface of the High Plain Aquifer ranges in elevation from 2,829 feet to 2,538 feet above sea level.

The Tribe has a monitoring network of 28 wells installed into the Aquifer (Figure 4). The ground water flow direction is toward the two perennial rivers, namely the Little White and Keya Paha, that flow through the Reservation. There are six offshoots that flow into the Little White River and, as determined from a discharge budget, the river is an effluent or gaining river. The river gains its discharge from the High Plains Aquifer. The net discharge ranges from less then 10 cubic feet per second (cfs) to more than 50 cfs. The river traverses for over 32 miles through the Reservation. The quality of the water is generally good, but there is potential for contamination.

The Reservation has 10 lakes/dams on the various creeks. They cater generally to recreation and occasionally to irrigation. The lakes suffer from eutrophication and nitrates. Phosphates, sulfates, and algae (Secchi disk reading) are often high.

Impact of Jurisdictional Conflict

The Tribe monitors the surface and ground water quality and quantity on a periodic basis. The South Dakota Department of Environment and Natural Resources also has a set of monitoring wells in Todd County. They periodically monitor the water levels in those wells.

The Tribe operates 16 center pivot irrigation systems to irrigate 1,860 acres, and there are 79 nontribal center pivot irrigation systems. The nontribal systems are operated under state permits within the exterior boundary of Rosebud Reservation.

Upon evaluation of the water table hydrographs of the 25 tribal monitoring wells, based on data generated for the last 10 years, it is apparent that the water table is falling in 12 monitoring wells, it is nearly status quo in 7 wells, and rising in 6 others. The hydrographs of some of the wells in which the water table is falling are depicted in Figure 5. The areas where the water table shows falling trends, rising trends, and status quo are depicted in Figure 6 (Huq, 1992).

It is easily visualized from the concentration of center pivot irrigation systems and areas of falling water table that

there is over pumpage of ground water for irrigation. Due to jurisdictional conflict neither the Tribe nor the state has a total grip on the problem so as to regulate water usage for irrigation and thereby stop the mining of ground water from the Ogallala Aquifer on the Reservation.

The U.S. Environmental Protection Agency (EPA) provides the authority to the Tribes for treatment as a state under the Clean Water Act provided the Tribe is federally recognized, has a governing body, has reasonable jurisdiction over the Reservation area, and has capable staff to manage the programs (sections 518 and 303 of the Clean Water Act). Having met all the criteria, Rosebud Sioux Tribe applied to EPA for treatment as a state. It was opposed by the State of South Dakota (Deputy Attorney General's letter dated September 18, 1990). However, EPA overruled the state's opposition and granted the treatment as a state to Rosebud Sioux Tribe (EPA Regional Administrator's letter dated December 11, 1990).

It has been reported by EPA that Rosebud Sioux Tribe can implement its programs on Water Pollution Control and Pesticide Enforcement over everyone including Indians and non-Indians within the exterior boundary of the Reservation under the Clean Water Act and the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) as amended. The Pesticide Enforcement Program of the Tribe under FIFRA has a code and certification plan approved by EPA in the *Federal Register.* However, implementation of the authority by the Tribe over non-Indians has not been tested in the court of law and hence the authority is not fully acknowledged by many non-Indians. The non-Indians on tribal or fee lands more often than not takes orders from the State Department of Environmental and Natural Resources and apply for and receive water use permits from the same department.

Ground water, as mentioned, is generally of good quality but is polluted in three areas by nitrates, hydrocarbons, and arsenic resulting from man-made activities.

There are several sources of nitrate in the area around the contamination site. A nitrogen isotope study (Sando, 1992) was conducted to determine the exact source of the nitrate. When nitrogen-isotope ratios relative to a standard are calculated as nitrogen in units per million (mil), it has been established that if the values range

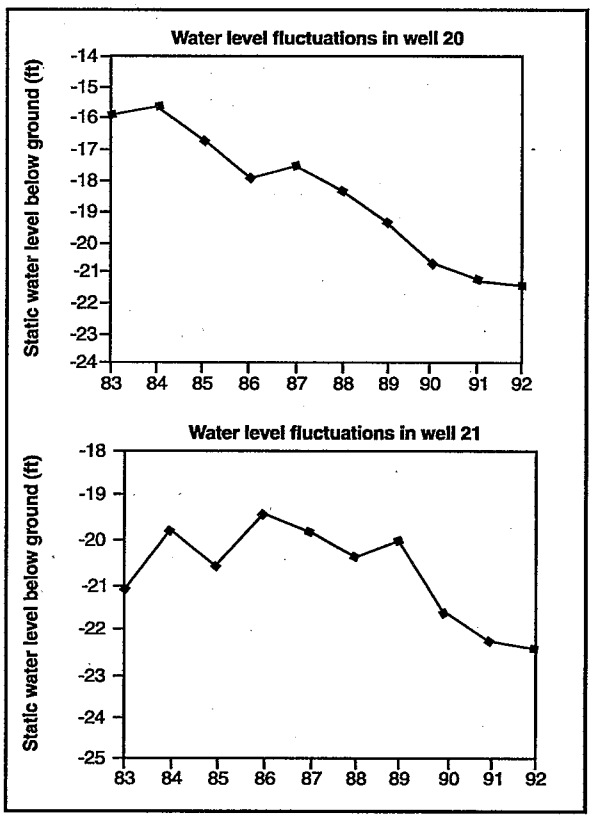

Figure 5. Hydrographs depicting falling water table in some of the monitoring wells.

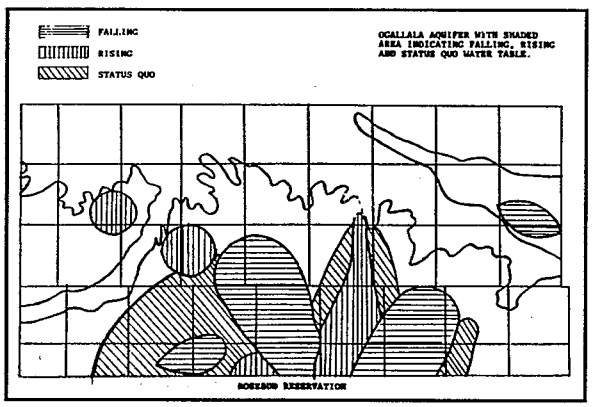

Figure 6. Areas delineated showing the trend of falling, rising, and status quo water table.

from 10 to 23 per mil, the nitrate is derived from septic systems and animal wastes; if it is less than 4 per mil, it is derived from commercial fertilizer; and if it ranges from 2 to 9 per mil it is a naturally occurring soil organic material. It is most applicable where the area is well drained and has highly permeable soil with a pH value of 7 or lower so that the nitrate undergoes little or no reaction. This scenario fits into the site

of nitrate contamination on Rosebud Reservation. The nitrogen isotope analysis of water samples from six wells indicated that the nitrogen isotope ranges from 10.60 to 11.80 in two wells, 1.40 to 3.70 in two other wells, and 7.30 to 7.90 in the rest. Hence, the source of nitrate probably is from animal wastes, leachate from rocks, or commercial fertilizer; all these sources exist in the area. There are feedlots and septic systems owned by non-Indians and the commercial fertilizer application is also mainly done by non-Indians, as can be visualized from the number of center pivot irrigation systems owned by non-Indians.

Ground water is also contaminated by hydrocarbons in the city of Mission on the Reservation. The contamination plumes have been delineated (Huq, 1990; TCT, 1992) and remedial actions are underway. Again the source of contamination is the gas stations owned by non-Indians and Indians.

A study on ground-water contamination by arsenic is underway and the potential source is herbicides/pesticides stored in bulk in the 1960s. The potential responsible parties of each of the above contaminations are not liable due to the confusion that exists on jurisdiction. The non-Indians cannot be tried in the tribal courts and the Indians in state courts. The only recourse probably is the federal courts, but the cost of law suits in federal courts frightens everybody, particularly the Tribe.

There are production wells that supply drinking water to several communities. The production wells are located on tribal lands, but they are surrounded by nontribal lands. Hence, Well Head Protection Areas (WHPA) delineated by the Tribe around the wells cannot always be implemented due to the fact that nontribal members in the delineated area do not have to abide by the tribal WHPA code.

Recommendations

EPA and other federal agencies must lay the groundwork for water resource management on Indian reservations without any ambiguity even if it displeases one or the other party.

The Indian tribes and the states must learn to respect each others' authority within their exterior boundaries and work in this direction, instead of trying to torpedo each others' authority.

In this game of water resource management, both ground water and surface water know no boundary and hence mechanisms to resolve differences between states and tribes on water quality and quantity management must be in place for easy incorporation. Antagonism and no cooperation between states and tribes is a no win situation for both parties and must be shunned.

Acknowledgments

This paper would not be possible without the assistance of Mr. Charles Mack, Mr. John Whiting, and Mr. Kevin Kvame of Rosebud Sioux Tribe's Water Resources Program. Ms. Patti Douville's (secretary) efforts are appreciated for word processing this report.

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Lowering Barriers to the P.L. 83-566 Small Watershed Program on the Navajo Nation

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The Navajo Nation consists of 6,736,840 hectares (16,640,000 acres) in Arizona, New Mexico, and Utah. This is an area slightly larger than the State of West Virginia. It is an area of outstanding beauty, as typified by Canyon De Chelly National Monument and Monument Valley.

Approximately 170,000 people, half of whom are under age 21, live on the reservation. Unemployment is about 20 percent, or nearly three times the national average. Nearly 50 percent of the Navajo people live below poverty level as compared to 13.4 percent for the United States as a whole. (Choudhary and Begay, 1989).

The Navajo Nation, like any other large area, has a variety of resource problems. These include a scarcity of irrigation water; erosion of range and forest lands; sedimentation of streams, rivers, and lakes; and flooding of villages and farmlands. These problems are building in magnitude because of increasing levels of population.

The Watershed Protection and Flood Prevention Act, Public Law 83-566, authorizes the Secretary of Agriculture to cooperate with state and local agencies in planning and carrying out works of improvement for soil conservation and for other purposes. It provides for technical, financial, and credit assistance by the U.S. Department of Agriculture (USDA) to local organizations representing the people living in small watersheds. Enacted in 1954, the watershed program is administered by the Soil Conservation Service (SCS). The general purposes of the program are to: prevent damage from erosion, floodwater, and sediment; further the conservation, development, utilization, and disposal of water; and further the conservation and proper utilization of land.

Public Law 83-566 was amended in 1975 to allow Indian tribes to be legal sponsors of small watershed projects. The SCS established four field offices on the Navajo Nation between 1982 and 1984 to work exclusively with Indian cooperators. The resource problems found on the Navajo Nation are eligible for assistance under the P.L. 83-566 Program. However, until very recently, no watershed work had been initiated on the Navajo Nation.

Historically, barriers to the small watershed program on the Navajo Nation have been many. These barriers can be categorized into two categories, institutional and cultural.

The largest institutional barrier has been the P.L. 83-566 program requirement that monetary benefits from project action be greater than monetary costs. This requirement made it very difficult to justify any project work in areas where costs of construction were high, but commercial and residential property values were low.

Another institutional barrier was the cost share requirement. The P.L. 83-566 program requires local sponsors to pay for land rights required for project construction. Local sponsors are also required to pay for up to 50 percent of construction costs for all purposes other than flood prevention. They are further required to provide the operation and maintenance needed over the life of the project. Low-income areas, such as the Navajo Nation, have had problems meeting these requirements.

A third institutional barrier has been the length of time required to move a small watershed project through the planning stages and into construction. This time frame can average 2 to 5 years depending upon the type of project being planned. This preponderance of planning time is due to a combination of required steps that must be followed and lack of personnel to deal with all of the identified resource problems.

Several cultural barriers have limited the effectiveness of the P.L. 83-566 program. First and foremost is the ownership of the land. In most cases individual ownership does not exist. Thus, it is difficult to identify the local decision makers when attempting to formulate a project. This is a real problem as the emphasis of the P.L. 83-566 program is on local participation and decision making.

Another barrier is the Navajo measurement of wealth. Wealth is measured in quantity rather than quality. For example, 100 poorly fed sheep would be worth more than 50 well-fed sheep. This philosophy makes it difficult to implement erosion and sediment preventive practices on rangeland.

A third barrier is the lack of operation and maintenance on water resource structures across the Navajo Nation. This lack of operation and maintenance appears to be twofold. First, there is not a good understanding of the reasons why operation and maintenance is so important. Secondly, no one individual is ever given responsibility for performing operation and maintenance. Thus, it is never done.

The SCS, the local soil and water conservation districts on the Navajo Nation, and the Navajo Tribe are working to overcome these barriers. The SCS is now emphasizing all beneficial effects equally when comparing benefits to costs. This means that environmental and social benefits have as great a weight as monetary effects when assessing the worth of a small watershed project.

The SCS has initiated policy that makes it easier for limited-resource areas to meet monetary benefit qualifications. Formulas, based on per capita income, unemployment rates, and property values, allow limited-resource areas to qualify for assistance with monetary benefits being less than costs.

Other formulas have been developed that ease the local burden associated with the cost share requirement. These formulas, based on per capita income, value of land and buildings, and percentage of protected groups, have reduced the local percentage of cost share required for a number of purposes under P.L. 83-566. The SCS is also placing greater emphasis on the local sponsors performing some of the required installation work in lieu of cash payments to meet cost sharing requirements.

The inordinate amount of planning time is being addressed in a variety of ways. The SCS has committed a greater portion of the budget to increasing staff for water resources planning. Regional water resource planners, primarily reviewers, have been commissioned to assist in planning projects for Native Americans.

Innovative planning procedures have been initiated. The Asaayi Lake small watershed project, on the Navajo Nation, is being formulated using consensus planning techniques. Consensus planning brings together federal, tribal, and individual technical expertise to discuss problems, solutions to the problems, and effects of the solutions. This eliminates many costly and time consuming studies.

The Navajo Nation leaders and the SCS are working together to initiate a comprehensive public participation process early on for the Asaayi Lake watershed. This process will help identify the decision makers in the watershed. It will also help tribal members gain a better understanding of the P.L. 83-566 program. They will learn how these projects become local projects once installation is completed; why operation and maintenance are so important to keep the projects functioning as they were designed; and why having too many animals on a piece of land can destroy the productivity of that land as well as causing sediment problems in downstream areas.

The Navajo people are a very visually oriented culture. Reading a watershed document does not give them a good feel for what is proposed and how it will look in relation to the landscape. The SCS will utilize image processing technology to help the Navajo people better visualize the measures that could be installed under a P.L. 83-566 project.

The P.L. 83-566 small watershed program has been available to the Navajo Nation for nearly 20 years. However, it is just within the last 6 months that the Navajo Nation has requested assistance under this program.

Their interest has been stimulated for two reasons. First, SCS, through discussions with the Navajo and other limited-resource groups, recognized the need to make the program more responsive to Native Americans, Afro Americans, and Hispanic peoples. Changes in P.L. 83-566 program policy have been initiated that make it more conducive for use by these groups.

Secondly, SCS, working through the Navajo Tribe and the local soil and water conservation districts, has worked hard at establishing real communications with the Navajo people. This has been accomplished by learning about their culture and tailoring communications in ways the Navajo people can understand and accept.

These changes should ensure that the P.L. 83-566 program will be a useful tool for the Navajo people well into the future.

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Managing Watersheds Through a Volunteer Teacher Network

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All across the land the single most important component to any successful grass-roots conservation effort is, in the words of concerned conservationists, "mobilize your populace!" In this era of shrinking budgets and cutbacks, the empowerment of the people with the knowledge and ethics of conservation issues may help to save not only our environment, but ultimately, ourselves. When educating the populace there are three frequently targeted audiences: students, homeowners, and teachers. By teaching students, one ensures the future efforts of a program in addition to recruiting enthusiastic participants. Programs educate homeowners, based on growing scientific evidence that residential home practices have a drastic and direct effect on our environment, particularly our watersheds. It is in the education and recruitment of teachers, however, that the key to establishing and perpetuating important conservation programs lies.

It is at the school curriculum level that the careful environmental strategies of watershed understanding and management will become reality. Once set in place, these programs educate students, their parents, and communities year after year. One teacher instructs an average of 90-120 students per day. Increasing public knowledge and awareness, as well as participation in key watershed issues, can have powerful results, and agencies have to respond to an active and responsive community of residents.

Methods

Watershed education is a broad-based topic involving many disciplines ranging from science and history (effects of land use) to math (flow rates). To successfully involve teachers, the teacher stream monitoring project started by the Prince William County Soil and Water Conservation District not only emphasizes ecosystem education, the effects of nonpoint source pollution, and proper nutrient management; it also strives to meet the state curriculum requirements (such as the Virginia Common Core of Learning and Education 2000 goals). The key to this program is integrating all of the basic studies into a comprehensive presentation that helps participants understand and solve watershed issues.

There is a tremendous need in U.S. schools today for environmental programs that utilize and expand current classroom curricula, as well as involving students in hands-on activities. Actual field experiences that utilize the curriculum and prove a focal point for teachers are in demand. The cornerstone of the district's watershed education program is to encourage teachers to adopt a section of a local tributary near their school, biologically monitor that tributary, and participate in reclamation or revegetation of damaged areas within their local watershed.

A volunteer teacher network was established in the summer of 1992; teachers agreed to "adopt" sections of streams locally and monitor them at least four times a year with their class. Instrumental in the formation of this program was the Prince William County School's Science Supervisor, who embraced the program, initiated important contacts, and assisted in formulating

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Students from Rockledge Elementary in Woodbridge, VA, sort through their stream sample net for macroinvertebrates. This sample site is within one of the larger tributaries of the Occoquan Reservoir.

curricula for teacher recertification workshops. Monthly teacher workshops for recertification credit were set up at the Prince William Forest Park Turkey Run Environmental Education Center (TREC); teachers were instructed in the Save Our Streams program (SOS) of the Izaak Walton League.

The SOS program assesses water quality through biological monitoring. We combined the SOS program with Soil and Water Conservation District programs to identify and solve point and nonpoint source pollution problems. Virginia has the important opportunity to submit student data to the Izaak Walton League of America. It then furnishes a yearly summary of data to the State Water Control Board for use in management decisions. These data are also reviewed by Prince William County's Department of Public Works Watershed Management Division office, as well as George Mason University and the U.S. Environmental Protection Agency (EPA).

Once incorporated into the school system at grades 3-12, the program acts as a catalyst for other environmental programs in watershed assistance: Earth Day cleanups in area streams, wetland mitigation planting projects for Boy Scouts and Girl Scouts, and science fair projects investigating water quality problems more thoroughly. EPA is currently coordinating watershed studies in which the teacher data will be used and classes will perform stream restoration projects at identified sites.

The benefit of a teacher-based program is that it provides reliable and viable volunteer data. All teachers are accompanied on their first sampling by a trained staff member. Teachers dependably collect data year after year. Attendance at periodic instructional and quality control workshops is high due to recertification credit approval. Volunteer programs involving the general public do not have these same long-term results.

Saving Money While Expanding Horizons

Because this program encourages monitoring watershed areas near school grounds, the critical problem of reduced budgets and field trip expenditures can be avoided. The program is beneficial to federal, state, and local agencies that welcome interaction with the schools and access to volunteer data they need. Area farmers, parks, and the Department of Public Works open their doors to workshops that show teachers' attempts to curb different sources of pollution such as sewage treatment plants and landfills. Tours of farms implementing best management practices (BMPs) such as slurry systems are exceedingly popular.

To introduce the impacts of proper land use management around the tributaries of our watersheds, participating teachers are offered boat trips onto the Potomac and Occoquan Rivers to observe the watersheds. The teachers sample water quality at the mouths of the various tributaries that they have adopted. At the end of a day of sampling, they compare the different results. Comparisons of tributaries with varying land uses surrounding them are quite enlightening. Much grant support is currently available for subsidizing the fees for conducting shipboard teacher workshops. Future plans for teacher collection of river data to be used by the Maryland or Virginia Departments of Natural Resources are in progress.

Interagency Cooperation

Programs that instruct teachers on watershed management, with a hands-on approach, attract the interest of a wide variety of agencies such as the Division of Public Works, Water Quality Boards,

National Park Service, EPA, U.S. Fish and Wildlife Service, and numerous universities. These agencies welcome and often seek the assistance of trained volunteers to help identify problems and collect needed data that may go uncollected because of budget cuts. Projects coordinated with these agencies include streambank rehabilitation, wetland mitigation, and water quality monitoring. These projects often need a larger work force than these agencies have available.

The Prince William County Department of Public Works Watershed Management Division not only provides sites that need monitoring, but also provides equipment and staff to assist in volunteer wetland planting operations as well as monitoring plans for the students. Private wetland plant contractors donate plant materials. The U.S. Army Corps of Engineers donates planting expertise. The U.S. National Park Service at Prince William Forest Park donates use of its Turkey Run Environmental Education Center for teacher training in stream monitoring and wetland plant identification. All agencies benefit by the existence of an active teacher network; teachers and students also learn of the vast array of environmental organizations that exist to serve them.

Stream Adoptions

When the program began in the fall of 1992, there was a series of teacher workshops on stream and watershed monitoring. The workshops inspired over 40 teachers to sign up to be volunteer monitors. By the spring of 1993, this number had doubled. Now more than 80 teachers participate as monitors of Prince William County tributary segments. The tributaries being monitored are part of the Occoquan and Potomac River watersheds, as well as ultimately part of the Chesapeake Bay watershed (Figure 1).

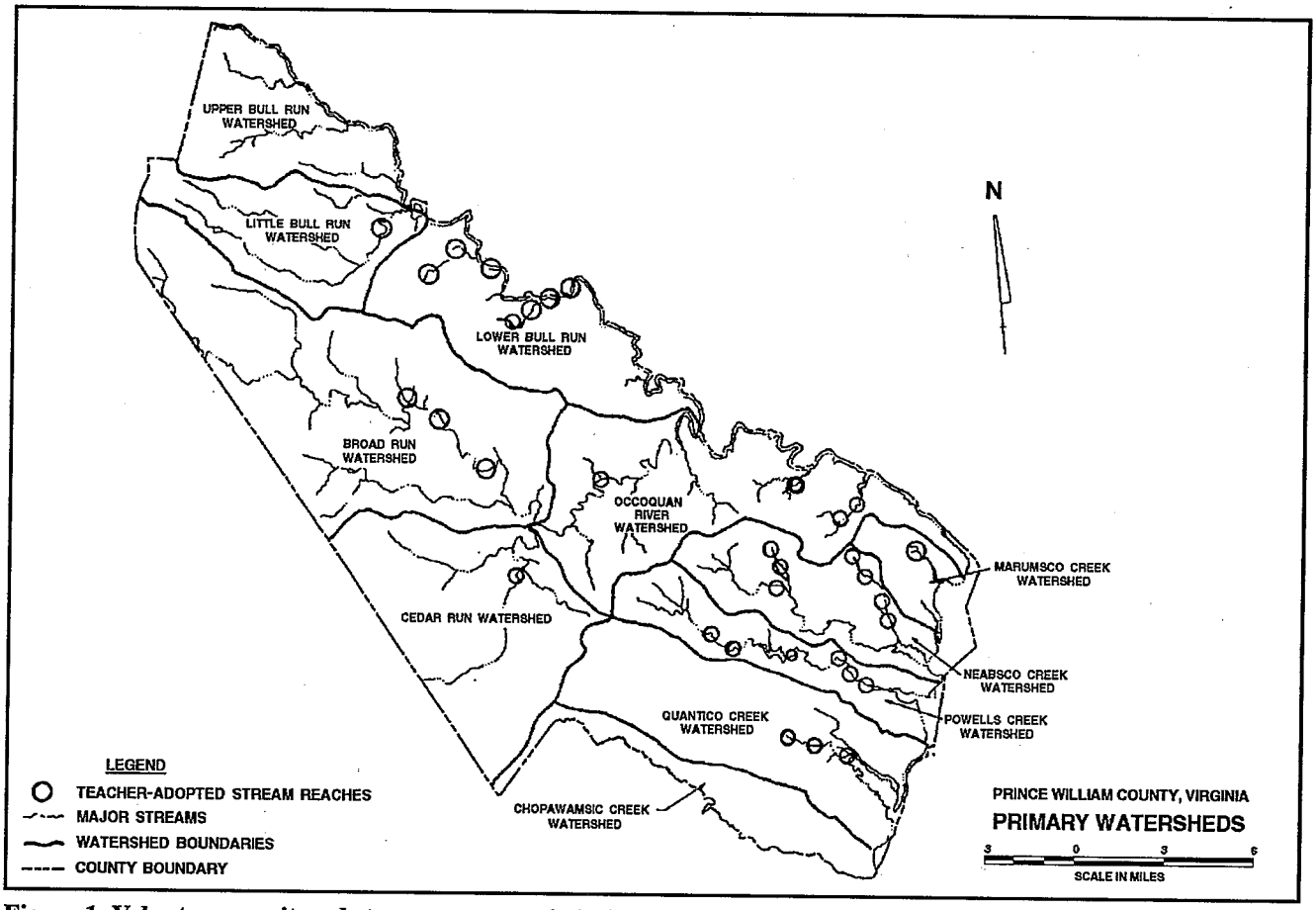

Figure 1. Volunteer-monitored stream segments in Prince William County, VA.

Teacher participants are expected to attend quarterly quality control workshops that feature inservice development activities: tests on macroinvertebrate identification, updates on sediment and erosion control regulations, and speeches from representatives of local conservation organizations. Discussions also include logistical considerations, such as transportation of students and handling private property owners. Teachers notify the district of their sampling dates; spot checks are made to ensure proper macroinvertebrate identification and sampling site selection. Reference collections of all insects sampled are encouraged. Streams in watersheds with relatively low human impact are used as a comparison with the monitored streams. Trips to these areas, such as Quantico Creek in Prince William Forest Park, illustrate the benefits of improving the environment of our watersheds.

By comparing their local watershed areas with the natural bounty and diversity of preserved watershed areas, teachers and their students become committed to protecting and rehabilitating their own locales. Their concern and awareness of the need for action is sparked by the often stark differences between local streams full of fly larvae and worms and preserved area streams rich in dozens of species of different macroinvertebrates—from stoneflies to hellgrammites.

A dedicated and diligent volunteer network, such as this teacher stream monitoring group, would be a tremendous benefit everywhere in the country. A larger nationwide volunteer effort would strengthen the comparisons and data base of such organizations as the Izaak Walton League; it would also help our nation and the environmental managers who very well may hold our future in their hands.

Successful Grass-Roots Strategies for Public Education and Participation In Watershed Protection Policy Making

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I am pleased to have this opportunity to discuss grass-roots strategies and their role in promoting public education and shaping public policy with respect to watershed protection. I represent a not-for-profit advocacy organization called the Citizens Campaign for the Environment (CCE). The organization's program is primarily focused on protection and management of land and water resources in the State of New York and coastal Connecticut. As a citizens' organization, CCE has developed a membership base of over 85,000 New York and Connecticut residents since its establishment in 1985.

This paper will review three examples of grass-roots public education and participation strategies on watershed protection issues conducted by CCE. All three examples involve utilization of a canvassing outreach program that is designed to implement each strategy.

The Canvass Outreach Program

A professional canvass outreach program is operated by CCE as its most effective method for communicating with citizens and generating public participation in policy making on a large scale. Canvassers provide one-on-one contact with citizens and are trained to supply them with verbal and written information on watershed protection and management issues. Additionally, canvassers provide citizens with information and guidance on how to effectively communicate with policy makers at various levels of government primarily through letter writing. By encouraging its members and supporters to become informed on the status of watershed protection issues over time, CCE has been able to successfully advance the process of developing public understanding and support for specific watershed protection policies and actions.

Suffolk County, New York, Drinking Water Protection Program

In 1987, a program was approved by Suffolk County government, through legislation and public referendum, to dedicate a portion of the existing county sales tax toward creating a $500+ million program designed to protect ground-water supplies. Known as the Suffolk Drinking Water Protection Program, its mandated priority was to provide funding and policy guidance for the public acquisition of strategic undeveloped watershed lands.

Suffolk County is located on the eastern half of Long Island, New York. The ground water under Long Island has been designated by the federal government as a *sole source aquifer*, meaning that a population of nearly 3 million residents relies exclusively on ground water as the only source of potable water supply. Approximately 1.5 million people reside in Suffolk County. Past studies of Long Island's aquifer system have identified certain watershed areas or zones that are of critical importance to the quality, rate, and depth of

ground-water recharge. From a policy perspective, the watershed areas that have been identified as *deep flow recharge* and *Special Ground Water Protection Areas* are high priorities for protection. Many water supply experts agree that the most effective protection strategy for watershed lands is through public acquisition when possible. The Suffolk Drinking Water Protection Program mandates that a minimum of 52 percent of the total funds generated over the life of program be used for public purchase of watershed lands.

Building the necessary public support for legislative adoption of the Drinking Water Protection Program, and later approval of a public referendum was largely accomplished through implementation of a comprehensive door-to-door and telephone canvass campaign throughout Suffolk County. Over a period of months, CCE representatives contacted residents in their homes and began to inform them of the relationship between watershed protection and the long-term maintenance of high-quality water supplies. Residents were made aware of the source of Long Island's potable water supply (ground water) and the negative impacts on ground water quality from various known and potential contamination sources, including inappropriate development, industrial discharges, accidents, and spills. Information was distributed about the general location of remaining undeveloped watershed lands and their role in recharging the aquifer system with high-quality water. Because much of Suffolk County experienced increasing development pressure during the 1980s, public concern about the need to preserve remaining open spaces was at a relatively high level. When the public became aware of the long-term environmental and economic benefits of comprehensive watershed protection, enthusiasm and support for legislative action on the proposed watershed protection program grew rapidly.

Using informational literature supplied by canvassing staff describing details of the proposed program, contacted residents were encouraged to communicate in writing with their elected representatives to express their point of view with respect to legislative adoption of the program. The literature distributed by CCE contained specific information on letter writing techniques, but did *not* include examples of letters that could be copied word for word. Hundreds of letters were generated in this manner. CCE was able to track the approximate number of letters generated because the majority were collected at the end of each day by the canvassers who originally made contact with the residents. The letters were unique in that they could not be regarded as "form" letters or "canned" mail by the receiving legislators and, therefore, each carried increased significance to the legislators. Each of the letters represented the point of view of a particular citizen, as he or she understood the issue, and was written in his or her own words. This form of public participation turned out to be highly effective in translating the public's awareness of the issue and support for specific legislative action.

Subsequent to the adoption of county legislation creating the program and passage of state enabling legislation to allow dedication of the sales tax, a required public referendum was held on election day 1987 to determine voter approval of the program. For several months prior to election day, CCE canvass staff distributed voter education literature throughout Suffolk County describing the program and explaining the language of the referendum. Voters approved the program by an 84 percent margin. This turned out to be the greatest voter plurality on any public referendum in Suffolk County history. A second referendum was held in 1988 that amended the program to allow for the issuance of bonds to accelerate watershed land purchases. This would enable the county to acquire some of the most strategic or "core" watershed parcels that were threatened with development. The referendum was approved by an 83 percent margin. The results of both referenda provided a clear measurement of the impact of comprehensive public education and participation strategies for watershed protection.

Albany, New York, Watershed Rules and Regulations

Approximately 100,000 residents of the City of Albany, New York, rely on potable water supplies that are stored in a system of two reservoirs. Both the Alcove and Basic Creek reservoirs are located outside the city limits surrounded by a relatively rural setting with mostly low density land uses such as agriculture. The reservoir watershed has been identified as an approximately 50-square-mile area. Water

quality monitoring by state environmental agencies has indicated that nutrient-rich runoff has begun to negatively impact water quality in one of the reservoirs. As suburban development and intensified agricultural practices have increased on the outskirts of the city, pollution threats to the reservoir watershed have become more visible. Under New York public health law, water purveyors, including municipal governments, are granted legal authority to develop, adopt, and enforce a system of *Watershed Rules and Regulations*. These regulations control land uses or activities within identified watershed zones that may adversely affect potable water supplies.

Historically, these regulations were first developed prior to the creation of federal, state, and local agencies with the specific regulatory task of protecting the quality of potable water supplies. Over time, the responsibility for regulatory enforcement has been largely shifted to these agencies, although water purveyors are usually most familiar with the status of the watershed and are directly responsible for maintaining water quality. Presently, the majority of water purveyors in New York either have not adopted their own specific watershed protection regulations or have regulations that are codified but are out of date and do not adequately address current water quality threats. This is the case for the City of Albany.

Albany's watershed rules and regulations were last revised in the 1950s. At the time, the most serious water quality threats resulted primarily from the location of cemeteries or deposition of human or animal wastes. The watershed regulations reflected these concerns by prohibiting those activities within certain distances from the reservoirs. Since the 1950s, new watershed pollution threats from a broader range of sources have become a reality including, but not limited to, solid waste landfills, industrial waste discharges, leaking septic systems, tank storage of petroleum and hazardous substances, erosion caused by improper development of slopes, road salting practices, and agricultural application of pesticides and fertilizers.

In 1989, CCE began a public education campaign in the City of Albany with the objective of building the necessary public support for comprehensive revision of the city's watershed regulations. After meeting with city officials to explain the organization's goals, CCE's canvass began to contact city residents to provide information about the source of the city water supply, the general location of the watershed area feeding the reservoirs, the purpose of watershed regulations, and who was responsible for implementation and enforcement. It was further explained that the city's existing regulations did not address many current watershed pollution threats and were in need of revision.

An initial challenge was successfully articulating the need for comprehensive watershed regulations. Most of the watershed area was still largely rural, and it was hard for the public to visualize pollution threats such as large industrial operations or high density residential development because, for the most part, they did not exist. It was explained that the primary purpose of watershed regulations was to *prevent* rather than correct pollution problems in the watershed. Residents were then asked to sign petitions urging revision of the watershed regulations as an effective pollution prevention strategy. Informational literature describing the role of watershed regulations was distributed along with letter writing guidelines. As a result, citizen generated letters urging specific revisions of the city's regulations were received by city water supply officials and the Mayor.

At first, city officials were hesitant to acknowledge the campaign because they were not accustomed to responding to the public on an issue that had been perceived as being largely technical and not one of great public interest and involvement. CCE recontacted Albany city residents during 1990 and continued to generate increased public interest and support for watershed regulation revisions. Thousands of signatures were obtained and over 500 letters were sent to city officials from residents stressing the need for revisions. As local print media became aware of CCE's campaign and started reporting it as a local environmental issue, city officials began to respond. In 1991, a review of the existing regulations was agreed upon along with a plan to develop needed revisions.

In April 1992, with the support of the mayor, the Albany Water Board voted to commit $30,000 for the purpose of conducting a sanitary survey of the watershed. The survey will comprehensively document land uses within the 50-square mile watershed including agricultural, industrial, and residential development. Completion of the survey during 1993 will allow the city to

identify existing inappropriate or "non-conforming" land uses within the watershed and enable the revised watershed regulations to properly address existing problems and most importantly, prevent future pollution problems within the watershed.

Through the creation of a data base of Albany city residents who have written to city officials, CCE is able to update those residents on the progress of the campaign and continue to educate citizens on the importance of watershed protection by encouraging greater public participation in the process of policy making.

Building Public Support for Control of Nitrogen Discharges into the Long Island Sound

The watershed of the Long Island Sound Estuary, bordered by the States of New York and Connecticut, contains perhaps the greatest population density of any major estuary in the United States. Long Island Sound's drainage basin includes the heavily urbanized areas of New York City, Long Island, and Connecticut. Over 20 million people live in the counties bordering the Sound.

In 1987, the Long Island Sound was included in the National Estuary Program (NEP) to conduct research on growing water quality problems. The resulting Long Island Sound Study (LISS) was designed to identify specific water quality problems and develop recommendations to improve and restore water quality. Among the highest priority problems identified by the LISS is the increasing incidence of a condition of little or no dissolved oxygen levels in water, called hypoxia. Hypoxia seriously impairs or kills various forms of marine life, particularly bottom dwellers such as lobsters, crabs, clams and oysters. The primary cause of hypoxia has been identified as an overloading of nitrogen into Long Island Sound from various sources, including sewage treatment plant effluent, storm water runoff, and atmospheric deposition. Nitrogen as a nutrient accelerates algal blooms that in turn decompose, depleting dissolved oxygen levels during the decomposition process.

Prior to its completion, the LISS determined that the problem of hypoxia was serious enough that it issued an important recommended action in a 1991 interim status report calling for adoption of a no net increase policy for nitrogen discharges. Adoption of this policy by the States of New York and Connecticut would limit or "cap" nitrogen loadings from wastewater treatment plants discharging into the Sound to a baseline of 1990 levels. This proposed action represented an important interim step towards stabilizing and ultimately reducing nitrogen loadings into the Sound. While the no net increase policy had been recommended, official adoption and implementation of this policy by state and federal regulatory authorities was not expected until sometime after completion of the LISS in 1993.

Shortly after the no net increase policy was initially recommended, CCE began a public education campaign within the Long Island Sound watershed to explain the problem of hypoxia and its relationship to nitrogen inputs resulting from human activity. The primary objective of the campaign was to build measurable public understanding and support for early adoption of the proposed no net increase policy. In May 1991, CCE canvass staff began contacting residents of the Long Island Sound watershed in both Connecticut and New York. Information about hypoxia and its identified causes was distributed to over 250,000 contacted citizens over a 4-month period. Once the objective was explained, citizens contacted through the field canvass were asked to sign statements supporting immediate adoption of the nitrogen policy. An official decision to adopt the no net increase policy was the responsibility of the LISS Policy Committee. This committee represented Regional Administrators from the U.S. Environmental Protection Agency (EPA), and Environmental Commissioners from the States of New York and Connecticut.

CCE began encouraging citizens who supported a nitrogen cap policy to write to the members of the Policy Committee and urge immediate adoption of the nitrogen policy. Again, letters were written that were the products of individuals based on their understanding of the issue. As the campaign progressed, the meaning of hypoxia became more fully understood by the general public as the media began paying attention to the issue and began to report about the causes and environmental impacts of this water quality condition.

On September 6, 1991, the LISS Policy Committee voted to adopt the no net

increase policy for nitrogen loadings. The States of New York and Connecticut agreed to implement the policy through modification of wastewater discharge permits. By September, over 60,000 signatures of citizens supporting the policy were obtained by CCE and submitted to the policy committee as documentation of public support. EPA reported a final tally of over 2,000 letters that had been received by the policy committee supporting the no net increase policy, while 15 letters in opposition were registered.

Through its campaign to build public understanding and support for implementation of this policy, CCE has been able to significantly increase public awareness of the vulnerability of the Long Island Sound Estuary to human activity within the watershed. The support created for this specific policy action has helped create a base of public understanding and support for further actions, particularly controlling nonpoint source pollution from runoff, that will be necessary to improve and ultimately restore water quality. Citizens are continuing to become aware that their individual participation clearly has measurable impact on the outcome and timing of policy decisions with regard to issues such as water quality protection.

Conclusion

The role of grass-roots participation in advancing public education and shaping policy on watershed protection and management is vital. As with most environmental issues, successful watershed management ultimately relies on strong public understanding and support. The experience gained through implementation of the examples described in this paper has been invaluable in helping to meet the challenge of building a public consensus on policies that will successfully address watershed protection and management issues in the future. From a grass-roots perspective, we look forward to meeting that challenge.

Operation:Future—Creating Tomorrow's Agriculture

Dennis W. Hall, County Extension Agent
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The subtitle "Creating Tomorrow's Agriculture" is admittedly a bit grandiose for a group of county extension agents and a small contingent of midwestern farmers to claim, but we subscribe to the theory that one should "make no little plans, for there is no magic in them to stir men's souls." Albeit a bold statement, the counties in the Big Darby Creek watershed are attempting to do just that.

In this paper, I hope to describe:

1. The setting in which this initiative was created.
2. Our vision of the agriculture we aspire to create.
3. Some of the educational activities we have conducted to date.
4. A few of the early successes we have experienced.

As you read this paper, you will note that I frequently use the pronouns "we" and "us." As the author of this paper, I represent many individuals. They include the farmer-leaders who have offered their credibility and experience to make Operation:Future a reality. They include a team of talented extension educators who have facilitated the development of this proactive approach. And they include many other public and private partners, including The Nature Conservancy, Soil Conservation Service, Ohio Department of Natural Resources (ODNR), U.S. Environmental Protection Agency (EPA), and many more. It would not be fair for any one of these groups to claim the successes of Operation:Future without recognizing the abundance of support given by many, many people.

Background

The Big Darby Creek, which flows in six west-central Ohio counties, is a remarkable natural resource. Although the scientific community has known this for a long time, it has not been until the last few years that the local residents have learned of its significance. Designated by ODNR as a "State Scenic River," U.S. Department of Agriculture (USDA) as a "Hydrologic Unit Area," and The Nature Conservancy as a "Last Great Place," this natural resource has been getting lots of environmental attention. Although it has been preserved in part due to the rich production agriculture which dominates its land use, nonpoint source pollution from farmland now threatens the stream's health. A diversified agriculture has been largely replaced by intensive row crop production of corn and soybeans. Sediment exists as the pollutant of most concern.

Farmers in the watershed were not sure how to deal with all of the new attention that was being sent their way. Rumors of outside influences telling farmers how they were supposed to farm was prevalent. A negative energy was mounting to resist the environmental movement they perceived as a threat to their values of independence and free enterprise.

Corresponding with these developments, extension agents in the four principal counties were crafting a new educational initiative called Operation: Future. This program would help farmers examine the forces of change in their industry and create their own plan for a superior tomorrow.

A New Model

Through Operation:Future a new and comprehensive model for production agriculture has been put forth (Figure 1). This model illustrates three forces of change which influence today's agriculture. These forces are agricultural competitiveness, environmental soundness, and social/ political issues. Competition has new meaning when former customers of Ohio grains are today aggressive exporters of those same products. Financial pressures lead farmers to adopt strategies they perceive to enhance profitability and lessen risk.

Many of these practices have a positive effect on the environment, but some do not. Environmental standards continue to evolve and agriculture must accept its responsibility in lessening nonpoint source pollution. The protection of endangered species and biological diversity is a relatively new challenge for the agricultural community and where feasible, farmers will respond.

As nonfarmers become more distant from today's agriculture, farmers have a responsibility to help consumers understand their food and fiber industry. Social/ political issues have new meaning when farmers account for less than 2 percent of Ohio's population, yet represent 60 percent of its land use. Nonfarmers are becoming more vocal about their expectations on topics such as water quality, food safety, and animal welfare, to name a few recent issues. Farmers need to demonstrate they are worthy of the public's trust if they are going to avoid the burdens of increased regulation.

Operation:Future seeks to identify and promote those technologies which are superior economically, environmentally, and politically. It is in this domain where everyone wins. Best management practices are a great start and will take us a long way in this area.

The outside circle of this model denotes what we call "Barriers to Change." It reminds us that an educational approach is insufficient if it enables the learners to overcome many barriers, which include financial, physical, and social. Further, we recognize people like to learn and do not like to be taught. Consequently, our educational approach is one which attempts to place learners in situations in which they can discover for themselves the underlying realities of their community.

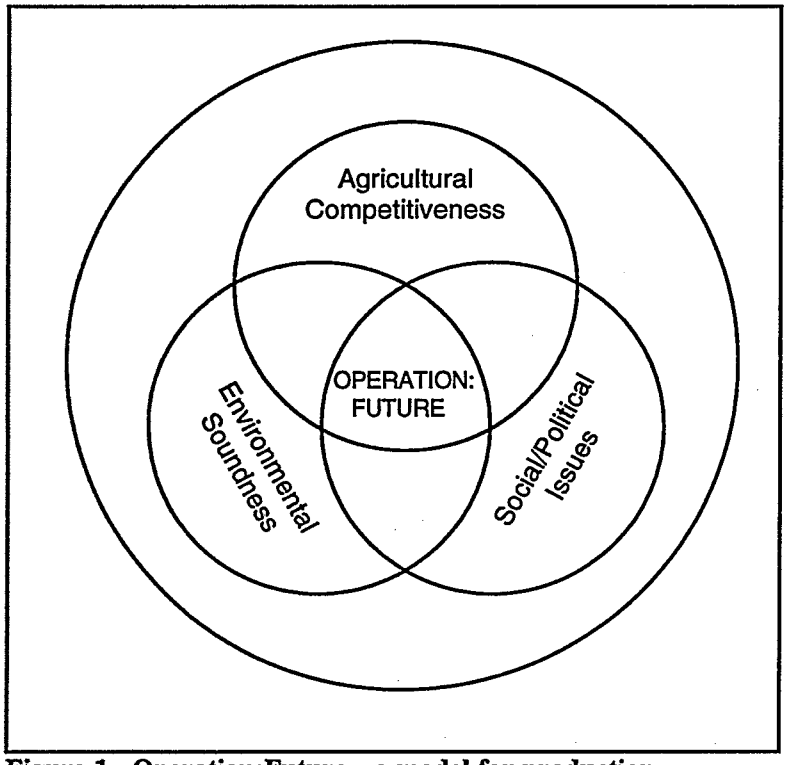

Figure 1. Operation:Future—a model for production agriculture.

Operation:Future Activities

Task Force Created

Highly respected farmers in the counties in which Darby Creek flows through were recruited to explore the current state of agriculture, including the water quality issue. Meetings included speakers who shared their perspective on agriculture and water management. Topics have included ODNR-Scenic Rivers, The Nature Conservancy, watershed management, and biological diversity.

Canoe Trip Conducted

Task force members were paired with conservation and environmental leaders to canoe Big Darby Creek. Educational demonstrations were conducted on the stream to help the participants understand Big Darby's aquatic diversity. Fish electroshocking, macroinvertebrates, and freshwater mussels were all featured. Discussions helped farmers gain a better appreciation for the stream and nonfarmers gain insight into

the economic and sociological characteristics of production agriculture. This program has proven so successful, it has been replicated 6 times with over 200 individuals participating.

Strategic Plan Developed

After many educational activities had been conducted, the task force conducted an all-day strategic planning workshop. A mission statement and priority activities were identified. To emphasize the importance of this workshop, letters of encouragement were sent to the task force membership by supportive partners in advance. The Dean of the College of Agriculture at Ohio State University provided opening remarks and described the important role farmers must play in charting their future.

Farmers as Co-Teachers

As the Operation:Future Task Force leadership developed, the farmers took on more responsibility as educators in the watershed. By assisting with canoe trips and on-farm demonstrations, conducting crop production contests (which include production, profit, and conservation components), and speaking at farm and nonfarm meetings, the farmers became the leading advocates for protecting Darby Creek.

Nonprofit Association Established

To further their mission, the task force created the Operation:Future Association (OFA). The first annual meeting was held with over 100 individuals in attendance. In its infancy, the association already has an active membership of 55 farm families. An elected board of 18 directors (3 farmers per county) now governs the association. Officers and standing committees provide OFA leadership.

Public Policy Tour

As the Clean Water Act approaches reauthorization, the OFA Board decided to visit Washington, DC, and discuss the various perspectives helping to shape nonpoint source pollution policy. Eight board members met with representatives from USDA, EPA, environmental and agricultural interest groups, and legislative assistants from House and Senate committees. After balancing the various views with their own personal experience, the farmers developed their own policy statements and shared these recommendations with their Congressmen.

Our Success Stories

Operation:Future has seen exciting success. Fear and uncertainty on the part of many farmers in the watershed has been replaced with an empowered voice of cooperation. For many, this ability to discuss differences and to seek win/win solutions is our greatest victory. Yet, our success is much deeper. Consider, for example, the magnitude of change some of our farmers have experienced. One farmer, who started from a very humble beginning, now farms with his family over 3,000 acres. A great source of pride for this individual is his ability to take a neglected piece of land and turn it into highly productive farmland. Some of the tools commonly used in years past to improve cropland (e.g., cleaning out ditches and subsurface drainage) are now considered environmentally detrimental. The notion of planting trees to enhance habitat and maintain streambanks is exactly opposite his perspective. This individual is working hard to learn how to farm in a manner which is more environmentally friendly and is dealing with a lot of personal tension trying to understand what is best.

Another farmer is discovering his own leadership ability. A highly respected farmer in the watershed, he has been a central figure in involving others in Operation: Future. Probably better than any other member, he has helped his colleagues to understand the water quality issue. Initially involved because of fears about the influence of nonfarm groups (government and others) on his farming operation, he has adopted a positive and proactive approach to nonpoint source concerns. Through the Water Quality Incentives Program, he is adapting improved conservation practices to his farm and working with others to encourage the same. Recently elected vice-president of OFA and expected to assume the president's duties next year, this farmer has been a classic example of the kind of individual Operation:Future aspires to develop.

For other farmers, just learning about the biological significance of the stream they have farmed alongside most of their lives has been an appreciated lesson. Now when in discussions of environmental protection in the Big Darby watershed, they have a better understanding of why and what they can do about it. Knowing that the stream is as healthy as it is today is in part due to its agricultural land use, has been an affirmation of their role as stewards and a cause for rededication to protect the area from uncontrolled urban sprawl.

The Operation:Future initiative has also added value to the overall partnership effort to protect Big Darby Creek. This partnership consists of many public and private organizations and is led by The Nature Conservancy. OFA's involvement provides both credible input to partnership activities and valuable output to the OFA membership. As the partnership effort continues to evolve, OFA's participation will be a valuable component of influencing positive changes in the watershed.

A Final Note About Success

You may note that this review of our success stories does not address specific improvements in water quality as a result of our educational agenda. While we are monitoring the behavioral changes via adoption of reduced tillage and other conservation practices, the Operation:Future initiative deals more on a personal level and with an individual's ability to influence destiny. Long term, it is the appreciation of our natural environment and the voluntary adoption of measures which protect and enhance it, that will create the success to which we aspire. We believe that through OFA we are helping our fellow citizens to participate in this worthy mission.

Green Shores for Mississippi Headwaters

Molly MacGregor, Director
Mississippi Headwaters Board, Walker, MN

Green Shores for Mississippi Headwaters combines local, state, and federal government, each with related but varying programs designed to protect water quality, to provide incentives to private property owners to keep livestock animals out of streams, improve shoreland appearance, maintain vegetated riparian corridors, enhance wildlife habitat, and improve water quality problems. This project enables local government administrators to use rules and regulations that were written from the traditional perspective of land use management, which protects shoreland corridors, to achieve objectives of watershed-based management.

Goals of Project

- Establish financial and technical incentives to enable shoreland property owners to establish management practices that reduce erosion, protect water quality, enhance biological diversity, and maintain vegetation on the shoreline.
- Implement watershed-based management in an area traditionally managed as a corridor.
- Coordinate local, state, and federal bureaucracy into a single working group.
- Build a conservation ethic among private property owners which is proactive in addressing management concerns.
- Create a mechanism to identify and recognize those who have adopted best management practices and provide an ongoing informal network of like individuals who can serve as advisors and leaders in local resource oriented management efforts.
- Maintain green shorelands on important water resources.

Participants

- *Aitkin County Land Department:* Manages public lands for multiple use within the county.
- *Aitkin Soil and Water Conservation District:* A county organization with funding from the state.
- *Aitkin County Local Water Plan Implementation Committee:* A county organization of individuals representing public agencies and private concerns, funded in part by the state.
- *Aitkin Soil Conservation Service:* A federal organization.
- *Aitkin Woodlands Council:* A committee of individuals interested in forestry on the county's privately owned lands.
- *Onanegozie Resource Conservation and Development Area:* An organization of several counties organized with federal assistance.
- *Minnesota Department of Natural Resources Regional Offices for Forestry and Wildlife:* A state agency administering forestry and wildlife locally.
- *Mississippi Headwaters Board:* An eight-county joint-powers river protection board.

Project Background

Local government managers want to maintain a green shoreline.

Private property owners want to minimize governmental interference in their lives and the operations of their businesses, such as farming and forestry.

Lawmakers are relying increasingly on locally administered and enforced regulations to protect shorelines. These rules are designed to fulfill a wide variety of objectives:

- Maintain an attractive appearance to the shoreland.
- Retain a vegetated corridor suitable for wildlife movement.
- Provide habitat for aquatic and water-oriented species.
- Protect fish and waterfowl habitat.
- Reduce erosion and sedimentation from the shoreline into the waterbody.
- Create limits that enable historic land uses to continue.

These rules are administered by officials at the county and municipal level.

Administration and enforcement is necessarily limited by the resources of the counties. For example, two or three people may have responsibility for a county that is one million acres in size and has approximately 20,000 property owners who may be affected by the rules. Secondly, enforcement of the rules depends to a large extent on the property owner's willingness to actually abide by the rules.

As has been noted frequently, effective administration and enforcement of local land use regulations and rules depends on the willingness of the private property owner to accept the limits prescribed by government. Even the most environmentally-minded property owner is likely to dispute the necessity of implementing rules on his or her property. Yet, most farmers and large lot owners are well aware of practices in which they commonly engage that contribute problems and are likely to become subject to regulation in the future.

Minnesota was one of the first states to implement shoreland management rules; yet, in the initial draft of those rules and in a substantial revision of those rules 15 years later, Minnesota avoided regulating the practice of allowing livestock to trample down river or lake banks along public waters.

Local land use regulators often find themselves in an awkward position when other shoreland owners understandably question the continuance of this practice when they are subject to rules on setback of buildings, wells, and individual on-site septic systems. And, the farmers, who constitute a strong enough voice to prevent adoption of the rules at present, do believe that they will be subject to such rules eventually. However, these farmers are unwilling to make changes in current practices, especially changes desired by government, without compensation for making the change. Local government believes it is cost-effective to encourage property owners to adopt desired best management practices in a friendly atmosphere—before the level of regulation is extended.

A final limitation of the current system of rules and practices is that most were developed with the goal of protecting corridors along streams and lakes and did not take a watershed-based approach. While most local government officials have accepted the challenge to manage a waterbody from its watershed, most available management tools are oriented either to corridors or to specific problems. Thus, a final outcome of the Green Shores project is that combining levels of government into a single organization moves the county toward watershed-based management of its important waterbodies.

Description of Resource and Resource Managers

The Mississippi River is a major watershed in Minnesota. The first 400 miles are under the jurisdiction of the Mississippi Headwaters Board (MHB), an eight-county joint powers board organized to preserve and protect the natural, cultural, scenic, scientific, and recreational values of the river (Figure 1). The MHB achieves this through administration of regulations that limit land use and building, water quality monitoring, and information and education programs designed to promote water and land conservation. The MHB was organized in 1980, when river protection was established according to a corridor, and maintaining attractive aesthetics was the primary goal. In recent years, the MHB has worked to establish a watershed perspective for river management.

For example, the MHB assisted the member counties in developing county Water Plans, a state-guided activity which resulted in the collection of relevant

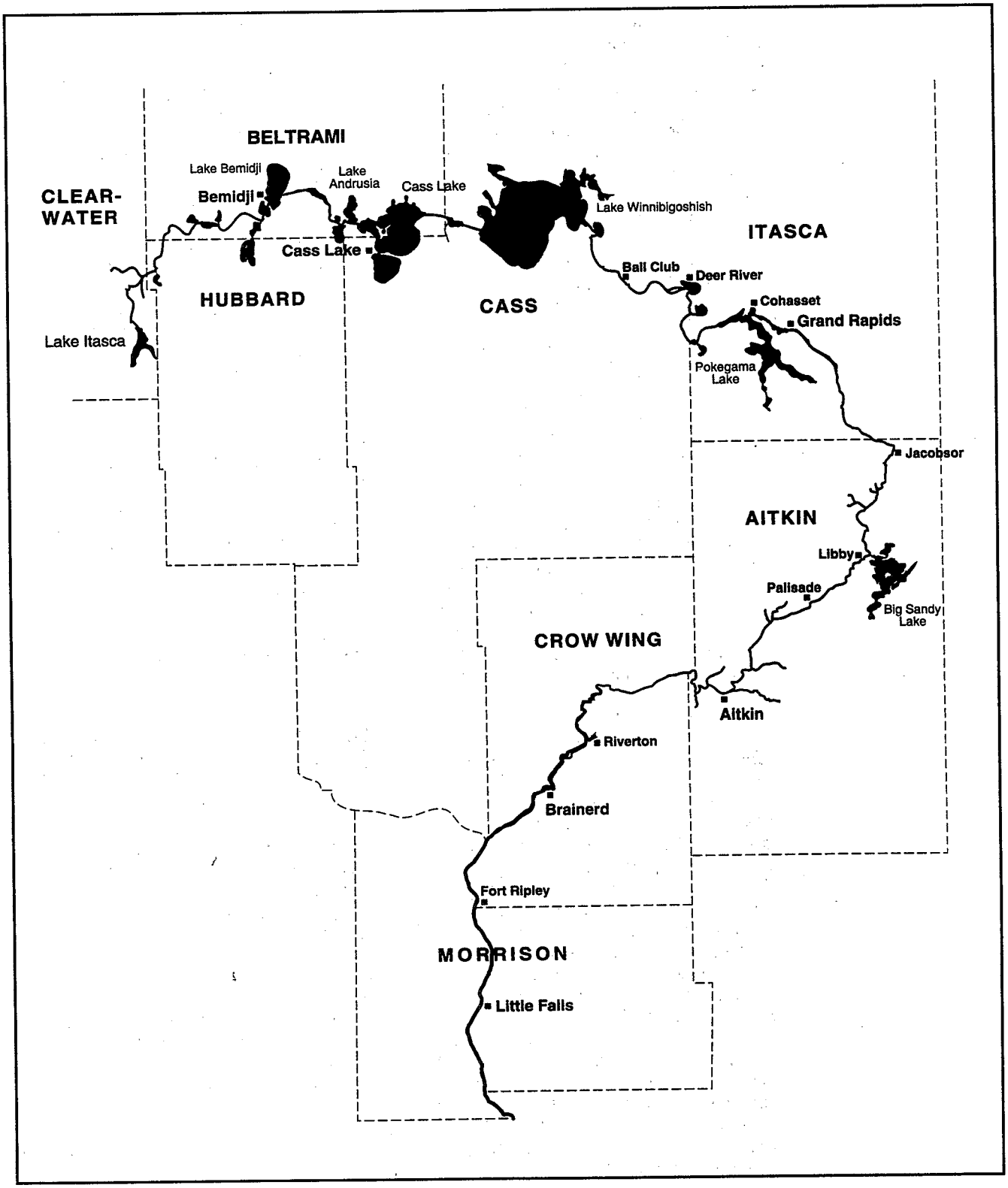

Figure 1. The Mississippi River in north central Minnesota.

information about the county's water resources by watershed and the development of specific management strategies for each watershed. These plans have been adopted by each of the MHB's eight member counties. The MHB is now using its resources to assist its counties in adopting the watershed-based management strategies. Because the reduction of erosion and sedimentation in the Mississippi River and related waters and improved administration and enforcement of land use regulations are goals of each county's Water Plan, the Green Shores pro-ject is being extended to all counties. However, it was established in Aitkin County.

Aitkin County is 1.1 million acres in area. The Mississippi River bisects the county, running more than 100 miles. The predominant land ownership in the county is public; however, the predominant land ownership in the river corridor is private. There are nearly 800 operating farms in the county, of which slightly more than half work with soil management programs.

Issues and Concerns from a Resource Perspective

Erosion and sedimentation are considered major water quality problems in the Mississippi River and its tributaries in northern Minnesota. The county is participating in the MHB's River Watch Project, which is an ambient water quality monitoring program. The water quality monitoring team is composed of a combination of students at the Aitkin Middle and High School and volunteers who live along the river corridor.

Maintaining a vegetated corridor along the river and lakes is considered a desirable outcome for water quality and the other values managed by the MHB, including cultural, recreational, natural, and scientific. Due to development, many riparian forest areas have become fragmented, lowering their suitability for many wildlife species.

Nearly half of the forest dwelling wildlife species found in Aitkin County are associated with riparian forest habitat. These forested riparian areas are traditional travel corridors for wide ranging mammals such as black bears, lynx, and fisher. Bird species associated with forested riparian areas, include bald eagles, wood ducks, barred owls, northern waterthrushes, pileated woodpeckers, and veerys. The majority of reptiles and amphibians utilize forested riparian areas for breeding purposes, including redbelly snake, common snapping turtle, blue-spotted salamander, and 10 species of frogs and toads.

Studies have shown that fish biomass was up to 127 percent higher in the river along rangeland in fenced study zones than in unfenced study zones. Grazing in forestland can reduce wildlife populations by up to 75 percent. Grazing of forestland lowers forest diversity by tree injury, soil compaction, and elimination of palatable species which promotes the unpalatable species.

Existing Programs

There are numerous rules and regulations guiding shoreland protection in Minnesota. Most of these are oriented to the shoreline and do not take a watershed perspective. Minnesota's Shoreland Management Standards, written by the Department of Natural Resources and administered by the counties, are intended to "preserve and enhance the quality of surface waters, conserve the economic and natural environmental values of shorelands, and provide for the wise use of water and related land resources of the state."

In 1987, the Minnesota Legislature authorized the county Local Water Planning process, which established comprehensive planning committees in Minnesota's 80 rural counties. With the assistance of the MHB, each of the Mississippi Headwaters counties has completed a plan, which lists reduction of erosion and sedimentation in important waterbodies and improves administration and enforcement of existing rules. Plans are administered by an implementation task force from public and private agencies.

There are a number of cooperative programs in Minnesota (as in other states) that encourage private property owners to manage lands to achieve publicly desired solutions. These includes the Woodland Stewardship Program run by the Minnesota Department of Natural Resources and the University of Minnesota's Extension Service. The Minnesota Department of Natural Resources has written best management practices for forestry, through a cooperative effort with a variety of public and private land managers. A current

challenge before the Department is recruiting private woodlands owners to adopt these best management practices. Approximately 80 percent of the state's private woodlands owners have waterbodies on their property.

Green Shores takes advantage of numerous federal cost-sharing programs for farmers, administered by the Soil and Water Conservation District and the Soil Conservation Service. These programs do not specifically list water quality protection as a desired outcome.

Green Shores for Mississippi Headwaters Conservation Project Guidelines

A. *Purpose*

The Green Shores for Mississippi Headwaters Conservation Project is established to encourage the protection of river shorelands through actions designed to reduce erosion, improve water quality, enhance wildlife diversity and promote aesthetic appearance of the corridor of the Mississippi River in Clearwater, Beltrami, Hubbard, Cass, Itasca, Aitkin, Crow Wing and Morrison counties.

B. *Applicability*

The following lands are eligible for participation:

1. Any area of privately owned land of at least 50 feet of shoreland frontage which is (a) crop field, (b) pasture, or (c) other open area or bare ground.
2. Reforestation of recently harvested areas, establishment of an orchard or Christmas tree plantation, are not allowed.
3. Determination of eligibility and extent of the management plan, approval of the applicant's plan and approval of completion shall rest with the agency designated by MHB. A property owner may request review of the decision by writing to the Mississippi Headwaters Board, which will make the final determination.

C. *Conditions for Participation*

1. A property owner who wishes to participate in the project shall make preliminary application to the local agency designated by the MHB, using forms provided by MHB.
2. The management plan should be designed to meet the goals of the project and of the property owner. Use of native species, and use of a diversity of species, are encouraged.
3. The property owner must agree in writing at the time of application to carry out the actions of the management plan; to maintain the practice for at least 10 years and to allow the MHB or its designated representative to review progress and make recommendations for changes at that meeting.
4. The participating property owner agrees to meet annually with representatives of this project. Participants will be asked to review progress and make recommendations for changes at that meeting.

D. *Policies and Conditions*

1. Project sites receiving funding through this program may also receive cost-share or other financial assistance through similar programs.
2. Project should create a buffer at a width no less than that established in the management plan.
3. All management practices should be conducted according to guidelines and rules established in Minnesota statutes and rules.
4. Participants will sign a conservation contract, pledging to leave the project site intact for at least ten years.
5. Payback of funds will be required if terms of the agreement are violated.

Project Organization

The Mississippi Headwaters Board is the fiscal agent and the responsible governing unit for the Green Shores project. A local sponsor is designated within each participating county. In Aitkin County, this is the Aitkin Soil and Water Conservation District. A technical committee is convened with representatives of appropriate agencies. The MHB has developed guidelines (above) and a contract for property owners that is tailored to meet each county's needs (next page). We are indebted to the Maryland's Green Shores project for this concept and basic organization.

The local sponsor is the chief recruiter for the project. Property owners who express an interest in participating are evaluated according to the following criteria:

- Location of property and affected waterbody.
- Current land uses and future land uses.
- Current management concerns and anticipated concerns.
- Goals of the property owner.

Following the initial contact, the technical committee reviews each applicant property, and where appropriate, assists in the preparation of a management plan, which identifies appropriate strategies, including planting grasses, shrubs, or trees; fencing; and construction of stock watering pits and others, that would reduce environmental impacts of current land use practices. The technical committee then assists the property owner in seeking appropriate cost-share funds. The Green Shores project provides up to $100 per acre of the landowner share for participating in these federal cost-share projects.

CONSERVATION CONTRACT

Green Shores for Mississippi Headwaters Conservation Project

1. The State of Minnesota, the Mississippi Headwaters Board, and Clearwater, Beltrami, Hubbard, Cass, Itasca, Aitkin, Crow Wing, and Morrison counties, are mandated to protect the natural, cultural, scenic, scientific and recreational values of the first 400 miles of the Mississippi River. This can be achieved, in part, through the maintenance of vegetation on the shorelands of the river, and the reduction of activities that lead to erosion.
2. The undersigned individual is interested in promoting long-term conservation of the Mississippi River and its shorelands.
3. The county and the individual have agreed to a Management Plan, a copy of which is attached hereto, which will protect the shorelands of the Mississippi River, by improving water quality, promoting wildlife and enhancing the appearance of the river. The terms and conditions of the attached plan are incorporated in and made a part of this contract.
4. A designated agency within the county will assist the individual in implementing and maintaining the Management Plan, by providing technical and financial assistance, including but not limited to, management assistance and direction, supplies, tools and long-term monitoring.
5. The individual pledges to implement the attached Management Plan for a period of not less than ten years, including an annual meeting to review status of the project and overall health of the river and its corridor.
6. This agreement shall become effective upon execution and shall terminate on _____.
7. In performing the terms of this contract, the property owner agrees to conform to all applicable federal, state and local laws and regulations, including the Minnesota Human Rights Act as it applies to employment connected to this contract.

_____ _____

Mississippi Headwaters Board Property Owner

_____

County Designated Agency

Participants are asked to make a 10-year commitment to the project and to meet annually to review achievements and to assist those entering the program for the first time. The technical committee will monitor each site for compliance with the plan and how well objectives of the plan are achieved.

Project Costs

Aitkin County and the Mississippi Headwaters Board have committed $4,500 to the first year of the project. Additional funds of $15,000 are being sought to extend it to seven other Mississippi Headwaters counties. At present, the only costs are the local land owner's share in federal programs to implement planting, fencing, or other desired practices. Participating agencies are contributing their time and expertise through routine staff commitments.

Educating Youth About Watersheds: Options and Actions

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Water quality is a critical environmental issue that has received deserved attention from educators in recent years. There are now a variety of educational materials for young people that can be used both in school and in after-school settings.

However, educators and youth leaders often do not have enough training to develop a water education program. They need help in including multiple objectives and information on curriculum activities for specific programs. The Cooperative Extension Water Curriculum Needs Assessment Project addressed this problem (Andrews, 1992a). We summarized information about water curricula, provided guidance for federal investments in water curriculum development, and created a network among national groups and agencies that promote youth water education.

Background

In 1988 state Cooperative Extension directors and administrators named water quality their highest national priority. These leaders head major county-based outreach programs at all 50 state land-grant universities. Cooperative Extension programs offer education to people of all ages in nonformal settings.

Water education became a focus for Cooperative Extension nationally. Leaders recognized that, while people of all ages need to understand water quality issues, there are bonuses when working with young people. Young people can also learn about leadership, identify career opportunities, and improve their science knowledge.

The Cooperative Extension National Water Quality Initiative Team soon began to support curriculum development. In 1991, wanting to maximize their investment by targeting the greatest needs, they began the assessment project and set up a review group of experts from private and federal organizations.

The plan was to guide Cooperative Extension policy and summarize water curricula for national, state, and regional water education leaders. Informal education needs were central to the project because that is the type of education Cooperative Extension generally provides.

Project Goals

This study is unique because it began with national water quality needs and issues rather than specific science or local resource education objectives. From these national resource policy issues we developed national goals and objectives for water quality education.

Water education materials are so many and varied it could take years to do a thorough assessment. To quickly meet educators' immediate needs for resources, we developed a short-term, initial project. The objective was to review and classify a selection of available curricula as a basis for understanding what was missing and needed. The results from this 6-month study should provide a strong beginning for future work.

The specific objectives of this study were:

1. Use national water quality issues to identify key water quality topics and

learning goals for youth in a nonformal setting (such as 4-H, for example).
2. Select water curricula to be reviewed. Identify water topics, environmental education goals, and delivery methods in each.
3. Determine strengths and weaknesses of available curricula.
4. Establish objectives for 4-H and youth water quality education, and provide direction for Cooperative Extension investment in curriculum development.
5. Present information about materials, delivery styles, and model programs in an easily understandable and accessible format.

National Water Education Needs

To determine national water education needs, we reviewed a number of federal and state Extension reports and national plans of work. We also reviewed reports from the U.S. Department of Agriculture, the U.S. Environmental Protection Agency, the Great Lakes National Program Office, and the U.S. Geological Survey. Members of numerous federal agencies contributed to our National Review Team. We sought the perspective of private organizations through a report by the Freshwater Foundation. Members of private organizations also served on the Review Team.

This process affirmed four critical national water resource issues that nonformal education could address, and developed a list of nine key water quality education topics.

Critical Water Quality Issues (*Extension Review*, Fall 1988)

1. Interaction of human activities and water quality.
2. Use and disposal of agricultural, industrial, and household chemicals.
3. State and local water problems such as drought-induced shortages, declining water tables, increased pumping costs, and increased production and treatment costs.
4. Protection for community water resource quality.

Key Water Quality Education Topics and Major Subtopics

A wide variety of water education material has been available for the last 10 years. It has not been easy for the educator, however, to choose the topics that help society meet its water quality goals or to find materials that teach those topics and concepts.

The National Review Team identified the nine key topics in the list that follows. Discussion also produced a set of important subtopics. These add detail that the educator can use and that we used in reviewing curricula. They are listed in Appendix A.

Key Water Quality Education Topics
1. The science of water.
2. Water-related ecosystems.
3. Drinking water supply: quantity and quality.
4. Water use.
5. Sources of water pollution and contamination.
6. Water quality: risk assessment and reduction.
7. Management and protection strategies for specific uses.
8. Government and citizenship issues.
9. Water-related careers.

In reviewing curricula, we looked only at whether the topics were present in the activities and information. We did not evaluate the quality of the activity or its relevance to the particular topic.

Environmental Education and Instructional Format Choices

In addition to learning about water, young people also need broader environmental problem solving skills, general science literacy, and awareness of water career options. The best way to learn these is through action and experience.

Because each person's choices and actions affect the environment, it is particularly important for young people to learn to think critically about and solve environmental problems. The Review Team based its choice of environmental education goals on the international effort to identify environmental education needs (Tbilisi Intergovernmental Conference on Environmental Education, 1978) and on a taxonomy of

environmental education objectives (Hungerford et al. 1980). We also used Gardella's inventory forms to help verify the environmental education goals we selected (Gardella, 1986).

Environmental education goals adopted for use include: ecological foundations, awareness of environmental issues and values, investigation skills, evaluation skills, and environmental action skills. Many of these goals also describe science literacy goals (American Association for the Advancement of Science, 1989).

Learning through experience is both vital to critical environmental thinking skills and easier to achieve in nonformal education. Furthermore, nonformal educators serve a diverse audience. We reviewed curricula for their attention to these needs.

Results

The report, *Assessing National Water Quality Education Needs,* identified a number of needs of interest to all youth water educators and some specific to the needs of watershed educators.

Appendix B summarizes some statistics about the availability of materials on topics relevant to watershed education. It is important to note that:

- Only half of the materials addressed ecosystem topics in general. Limited resources are available on specific ecosystems such as lakes, rivers, wetlands, or streams.
- Half of the materials provided activities about point source contaminants, but less than a quarter presented information about nonpoint source contaminants.
- Forty-two percent of the materials reviewed identified risks related to specific contaminants, a quarter described impacts of contaminants, but only 2 percent helped youth think about how risk decisions are made.
- About a quarter of the materials provided education about government and citizenship issues related to water.

Other key findings indicate that activities created by a partnership between the school, community groups, and resource professionals are most likely to achieve water education goals. They can help by providing:

- Training for teachers and youth leaders about water topics.
- An integrated approach to the significance of ecosystem components to water topics (many materials present each ecosystem separately and do not relate them to each other or to water issues).
- Assistance to integrate ecology and science study into everyday life activities.
- Opportunities to learn by doing, in the community.

Review of materials designed specifically for watershed education identified some strengths and some gaps. Community-based educators can provide opportunities that fill in the gaps and enhance the youth's ability to grasp the concept of the watershed and what it means to his or her life. To identify further resources, consult a publication available through the Cooperative Extension Service, *Educating Young People About Water* (Andrews, 1992b).

To help youth understand why we are concerned about watersheds, the educator can:

1. Create a sense of place through field trips and activities within the watershed.
2. Identify what activities take place within the watershed.
3. Investigate how these activities affect water.
4. Provide opportunities to investigate why we care about water quality, especially its impact on: drinking water, habitat, recreation, and human habitation.
5. Practice taking personal actions to prevent water contamination.

Activities likely to improve youth understanding include:

1. Taking trips to sites within the watershed that demonstrate varied land uses.
2. Having youth create their own map of what's happening where in their watershed.
3. Interviewing local water officials about water quality impacts and pollution prevention activities.
4. Identifying and carrying out restoration activities, such as streambank restoration.
5. Inventorying home and/or school waste management and property care

Photo courtesy of Chester Arnold, University of Connecticut.

activities. Identify ways to reduce nonpoint source pollution through improving these activities.

6. Studying a specific municipal activity and make recommendations to keep or change it, such as measuring chloride present in storm drain outflow.

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APPENDIX A

Water quality education topics and major subtopics

As you select or develop activities and curriculum materials for water education, consider these water topics. This list will also help you better understand the curriculum summaries in the curriculum summary chart.

1. Science of water

- ___ Properties
- ___ Importance to living things
- ___ Hydrologic Cycle
- ___ Geology/hydrology dynamics
  - ___ surface water
  - ___ groundwater
  - ___ regional supply

2. Water-related ecosystems

- ___ Types of ecosystems
  - ___ lakes
  - ___ wetlands
  - ___ estuaries
  - ___ rivers
  - ___ watersheds
  - ___ ephemeral systems
  - ___ ponds
  - ___ oceans (intermittent)
  - ___ streams
  - ___ riparian
- ___ Major regional resource:

  _____

  (insert name)
- ___ Ecological concepts

3. Drinking Water Supply: Quantity & Quality

- ___ Delivery
  - ___ community/public
  - ___ private
  - ___ treatment of drinking water
    - ___ public drinking water
    - ___ home treatment
- ___ Water Quality Control
  - ___ well concerns
  - ___ testing
    - ___ public
    - ___ private
- ___ Lifestyle impacts/ conservation

4. Water use

- ___ Use of water by many groups
  - ___ commercial
  - ___ municipal
  - ___ recreation
  - ___ industry
  - ___ domestic
  - ___ agricultural
  - ___ power production
- ___ Conservation by user groups
- ___ Issues/conflicts between user groups

5. Sources of Water Pollution/ Contamination

- ___ Point source
  - ___ agricultural sources
  - ___ public and/or private wastewater
  - ___ industrial and business hazardous wastes
  - ___ energy production wastes
- ___ Nonpoint source
  - ___ atmospheric deposition
  - ___ agricultural
  - ___ forestry
  - ___ urban
  - ___ mining

6. Water quality: risk assessment & reduction

- ___ Curriculum addresses the concept of how risk decisions are made
- ___ Impact of water quality on health
- ___ Impact of water quality on human food sources
- ___ Impact of water quality on plant and animal communities
- ___ Understanding and reducing risks for specific contaminants
  - ___ bacteria
  - ___ nitrates
  - ___ pesticides
  - ___ salinity
  - ___ sediments
  - ___ other chemicals:

    _____
- ___ Water quality indicators

7. Management & protection strategies for specific uses

- ___ Zoning strategies
  - ___ shorelands/floodplains
  - ___ wetlands
  - ___ wellhead/groundwater recharge areas
- ___ Chemical storage
- ___ Recreational use
- ___ Wastewater treatment
- ___ Solid waste management decisions
- ___ Agricultural management practices
- ___ Wildlife habitat/land stewardship management
- ___ Natural disasters
- ___ Chemical emergencies
- ___ Development issues/pressures

8. Government & citizenship issues

- ___ Policy issues
  - ___ water quality
  - ___ water quantity
- ___ Role of local government in developing protection strategies
- ___ Citizen involvement and participation
- ___ Legislation, regulation, incentives/disincentives

9. Water-related careers

- ___ Technical:

  _____

  _____
- ___ Professional:

  _____

  _____

Water quality education topics and major subtopics was developed by Elaine Andrews and Karen Poulin, University of Wisconsin Cooperative Extension, Environmental Resources Center, 1992.

APPENDIX B

WATER-RELATED ECOSYSTEMS	% CURRICULA
Types of ecosystems	**54%**
• lakes	12%
• rivers	11%
• ponds	12%
• streams	23%
• wetlands	22%
• watersheds	20%
• oceans	14%
• riparian	2%
• estuaries	11%
• ephemeral systems (intermittent)	9%
Major regional resource	**22%**
Ecological concepts	**48%**

POLLUTION/CONTAMINATION SOURCES	% CURRICULA
Point source	**51%**
• agricultural	18%
• wastewater (public or private)	42%
• hazardous waste - industry or business	35%
• energy production wastes	15%
Nonpoint source	**22%**
• agricultural	31%
• urban	32%
• forestry	6%
• mining	8%
• atmospheric deposition	12%

The Save Our Streams (SOS) Program

Karen Firehock, Save Our Streams Program Director
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Mobilizing Volunteers to Monitor and Restore River Water Quality

The Izaak Walton League of America's Save Our Streams (SOS) Program is a grassroots river protection and restoration program active for 24 years in more than 37 states. SOS provides volunteers with a simple and effective way to survey their watersheds for pollution sources, monitor water quality using a biological approach, and initiate restoration activities to solve pollution problems. Thousands of volunteers around the United States currently use SOS to provide personal stewardship for their rivers.

SOS Program Goals

The goals of the SOS Program are twofold: to educate the public about water quality and to collect vital data on the condition of rivers and streams. The goals of public education and collection of water quality data are considered equally important. An educated and motivated public is critical to protecting the health of rivers and streams while information on the status of those waterways is needed to recognize and solve pollution problems.

Many government programs require soil erosion control and animal waste management, and advocate wise nutrient and pesticide use with the primary goal of protecting water quality. However, very few data exist on the quality of receiving streams, rivers, and lakes. In addition, farmers are asked to use best management practices (BMPs). However, they do not often have adequate knowledge of the effects on water quality of their farming operations and the benefits that could be gained from instituting expensive BMPs.

The SOS Program enables citizen groups, farmers, local businesses, and state and local governments to have a cost-effective tool to assess current water quality status. SOS can also be used to document improvements made through installation of BMPs. SOS uses a biological monitoring technique to assess the quality of a stream or river. SOS volunteer collected data have been used in state 305(b) reports, county watershed assessments and growth plans, resource mapping, pollution compliance monitoring, long-term trend analyses, and for educational purposes such as state park interpretive programs and environmental education seminars. By using a partnership approach that involves government, schools, citizens, and business, SOS can achieve unique solutions for watershed stewardship and ongoing resource protection.

The SOS Network

The League runs statewide SOS programs in Virginia and West Virginia. SOS staff conduct workshops, publicize the program through press releases and media interviews, review and approve volunteer collected data, instruct volunteers in monitoring and watershed survey techniques, and run quality assurance and quality control procedures for the program. SOS staff also write fact sheets and books on water quality and resource protection issues. In other states, such as Louisiana or Minnesota, SOS staff may provide guidance to states on how to set up their own statewide networks and provide training in working with volunteers and setting up volunteer monitoring programs. The MONITORS data base is used to track projects in all 50 states and some foreign countries. SOS staff

can provide information to the public, media, or government programs located in their states or other states.

SOS volunteers include all types of people. SOS volunteers include ambulance drivers, professional jockeys, scientists, teachers, students, families, employee unions, developers, recreationists, and anyone who cares about the future of the nation's waterways. SOS volunteers range in age from 2 to 92.

Many Ways to Get Involved

Participants become involved in the SOS program in many different ways. The public may learn about an SOS project through one of the Izaak Walton League's 400 chapters. They may also read about SOS in many educational or scientific journals, or they may learn of SOS through articles in newspapers and magazines. Word-of-mouth is another, not to be overlooked, method of advertising. Many volunteers and government agencies refer contacts to the SOS Program. People may also become involved in SOS through attending a hands-on SOS workshop in their local community sponsored by a League chapter or SOS program staff.

Participation in the SOS Program is free. Volunteers can sign up to monitor a particular river or stream using a postage-paid card in their SOS kit. That information in managed by the SOS database called MONITORS. When a volunteer signs up to conduct a project, SOS staff make sure that the adopted river is not currently being monitored by other volunteers. If the river is already adopted, SOS staff ask the volunteer to work in cooperation with the other volunteers. There are two reasons for this. First, duplication of effort by volunteers should be avoided whenever possible; second, rivers should not be monitored to the point where the resource may be harmed. For instance, SOS monitoring stations are usually spaced at least a quarter mile apart and monitored only once every 2 months to minimize disturbance of the river bottom.

Photo courtesy of Laury Marshall-Forbes

Save Our Streams volunteers learn to identify aquatic insect larvae and test water quality.

A Hands-On Approach

The SOS program has grown rapidly for the past 24 years because it provides the public with a hands-on approach to resource protection. As knowledge of environmental problems has become widespread, people want to know what they can do personally to protect the environment. The SOS Program offers volunteers a way to get involved to protect rivers and streams in their own backyards.

Simple Steps to Success

People who are concerned about their role in protecting the Earth find a great deal of gratification in SOS because it provides a step-by-step way to attack environmental problems and solve them. Simply stated, the SOS methodology can be summed up as follows:

1. Do your homework.
2. Form a network.
3. Create a workable plan.
4. Implement the project.

Doing your homework involves learning about the problems facing the river or stream by surveying land uses in the watershed, reviewing industry discharge permits, state river assessments and management plans, interviewing landowners and community planners, and researching relevant scientific issues.

Forming a network requires enlisting the help of others to determine and address environmental problems. Utilizing community groups such as League chapters, other conservation groups, schools and universities, state agency personnel and community planners, volunteer agencies, and interested community members should maximize the success of the project.

Creating a workable plan requires identifying the problem or the main goals of the project such as gathering data on the river to develop a management plan;

preventing excessive stream sediment by reducing storm flows and stabilizing streambanks; conducting river trash clean-ups; improving fish habitat through structural and water quality modifications; restoring native fish species; or many other projects. A successful plan has both short- and long-term goals and divides the work up among many diverse participants.

Implementing the project involves getting the project started and having regular meetings with participants to discuss problems and reevaluate the approach as needed. Implementing the project also requires rewarding hardworking volunteers and utilizing the media to enlist community support for the project. If needed, grants can be sought to provide for short- and long-term project funding.

The key to building public support for the project is in motivating the public to participate and involving many different people. The main message of SOS is rivers and streams need help from people. SOS communicates to the public that government cannot do the job alone. Since only 36 percent of U.S. rivers and streams are monitored by government agencies, volunteers are needed to help cover the remaining 64 percent that are unmonitored and unprotected. In addition, stream pollution problems can best be solved by participation at the local level where pollution problems often start.

Something for Everyone

SOS involves many different people because it offers something for everyone. Projects can be as simple as a stream cleanup or as complex as a watershed inventory and river monitoring program including restoration projects. SOS projects can also make use of participants' many different talents: writing, newsletter design, knowledge of stream chemistry or biology, computer data management, word processing, public speaking, gardening, tree planting, carpentry—for wood duck boxes or bird blinds for wildlife viewing, artwork for the project, teaching skills or just enjoying getting wet.

The SOS Monitoring Method

Volunteers also gain an understanding of water quality issues in their watersheds. SOS volunteers use a simple water quality monitoring method that involves collecting stream macroinvertebrates—aquatic organisms large enough to be seen without a microscope—and recording the numbers and types of organisms present in their stream. The macroinvertebrates include familiar stream organisms such as crayfish, stoneflies, clams, aquatic worms, and other common stream organisms. The organisms are collected with a fine mesh net supported by two poles, known as a kick-seine. After collection and identification of the macroinvertebrates, volunteers fill out a simple SOS survey form that results in a water quality rating for their stream of excellent, good, fair, or poor.

Volunteers are also taught how to solve the pollution problems they discover after surveying their watershed. SOS staff and materials provide advice for solving pollution problems from sources as diverse as factories to golf courses. SOS volunteers are able to call a toll-free helpline for advice on solving stream pollution problems.

Easy-to-Understand Materials

The key to the SOS program's success is that all materials have been written to be easily understood by a lay audience; scientific issues and terms are clearly explained. All materials in the program receive extensive field testing and review before they are printed. A 28-minute VHS training video takes volunteers step-by-step through the monitoring procedure and explains the volunteer's role in monitoring and protecting rivers and streams. The SOS Kit, available from the League for $8, contains brochures on water quality and guides to recognizing and solving pollution problems. Other guides to restoring stream habitat or enforcing state laws are also provided. All materials are priced to be easily affordable to the general public.

Overcoming the Skeptics

Obstacles faced by the program have included skeptical scientists, wary government agencies, and apathetic volunteers. However, SOS staff and volunteers make a point of meeting with scientists and government agencies to educate them about the SOS program. They are invited to review and critique methods, materials and quality assurance, and quality control procedures.

TV and radio interviews and press releases are used to educate the public on the need for their involvement. The SOS philosophy is one of cooperation.

SOS staff meet with state and local agencies before a monitoring project is begun to ensure that all users of the information agree with the methods, training, and review that are planned. SOS staff have improved and revised materials based on input from state and federal agency participants. SOS staff field-test new materials with volunteers on a pilot basis first to make sure that materials are easy-to-understand and provide credible results. SOS staff also periodically review and revise materials to make sure that they are consistent with new scientific knowledge. An approved quality assurance quality control plan is always available for review by interested parties and is periodically reviewed by the U.S. Environmental Protection Agency (EPA).

Keeping Volunteers Motivated and Active

Volunteers stay active in the SOS program for many years because there are always new projects for them to do and new information for them to learn. If SOS were simply a water monitoring program, volunteers might become complacent or bored with the program. However, SOS water monitors have become involved in reviewing discharge permits for industry and wastewater treatment plants, writing county zoning ordinances, working with local schools to implement SOS projects, improving stream habitat by stabilizing streambanks, stocking fish in restored streams to bring back native species, working with golf courses and farms to implement integrated pest management programs, constructing wetlands for reducing storm flows or treating wastewater, working with dairy or beef cattle operators to fence cattle out of streams and install other cattle BMPs, and many other projects.

SOS materials provide "how to" guidelines for many of these projects, and SOS staff offer technical advice to volunteers in getting projects implemented. SOS also sponsors workshops and conferences to bring participants together to share good ideas and opportunities. SOS co-sponsored and organized the Third National Citizens' Volunteer Water Monitoring Conference in 1992 at which 40 states were represented by governments, educational institutions, environmental groups, businesses and volunteers.

Rewarding Volunteers

Most successful volunteer programs include a method for motivating volunteers on a personal level. However, to keep volunteers motivated and make them feel appreciated, it is important to say "thank you." SOS staff provide volunteers with adoption certificates for their particular stream project; they also have appreciation certificates for a job well done. Unlike some programs, SOS operates on a shoestring budget and does not offer T-shirts and hats to volunteers as some programs are able to do. However, regular communication with volunteers by staff as well as recognition at retraining workshops and conferences are one way to show support for volunteers. Most volunteers want to know that their work is important. SOS staff make a point of showing volunteers how their data are used by state agency personnel and provide feedback on collected data.

In summary, the key aspects of any successful public participation program are:

- Clearly defined goals and a clear plan of action.
- Easy-to-understand materials.
- Involvement of many diverse people and skills.
- Review by interested parties.
- Different levels of participation from simple to complex.
- A reward system for volunteers.
- Regular publicity for the project.

The Grand Traverse Bay Watershed Initiative: A Local Partnership at Work

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Background

The Grand Traverse Bay is a high-quality embayment in northern Lake Michigan, widely recognized for its outstanding recreational features and relatively nondegraded water quality. The Bay itself covers approximately 360 square miles. The surrounding Grand Traverse Bay watershed encompasses approximately 973 square miles of land, which serves primarily agricultural, forestry, and recreational uses. Population in the watershed was approximately 80,000 in 1990, with the town of Traverse City accounting for about 15,000 of those people. Population in the watershed has increased dramatically over the past two decades (about 30 percent between 1970 and 1980, and more than 15 percent between 1980 and 1990). Another 20 percent increase is forecasted over the next two decades.

In response to this significant growth, early efforts to maintain the high quality of natural resources focused on addressing specific problems or threatened resources, such as erosion sites and nonpoint source pollution along the Boardman River and Mitchell Creek, two major tributaries to the Bay. Broader evaluation efforts (Battelle, 1992) began to indicate that nonpoint sources of nutrients, and possibly sediment and other pollutants, were the primary factors controlling the quality of watershed resources. As the scientific community began to widely recognize nonpoint source pollution as a major threat in the Great Lakes basin, leaders in the Grand Traverse Bay watershed made a conscious shift to begin managing resources on a watershed-wide basis.

The Grand Traverse Bay Watershed Initiative was formed in 1990 as a local, long-term watershed management program.

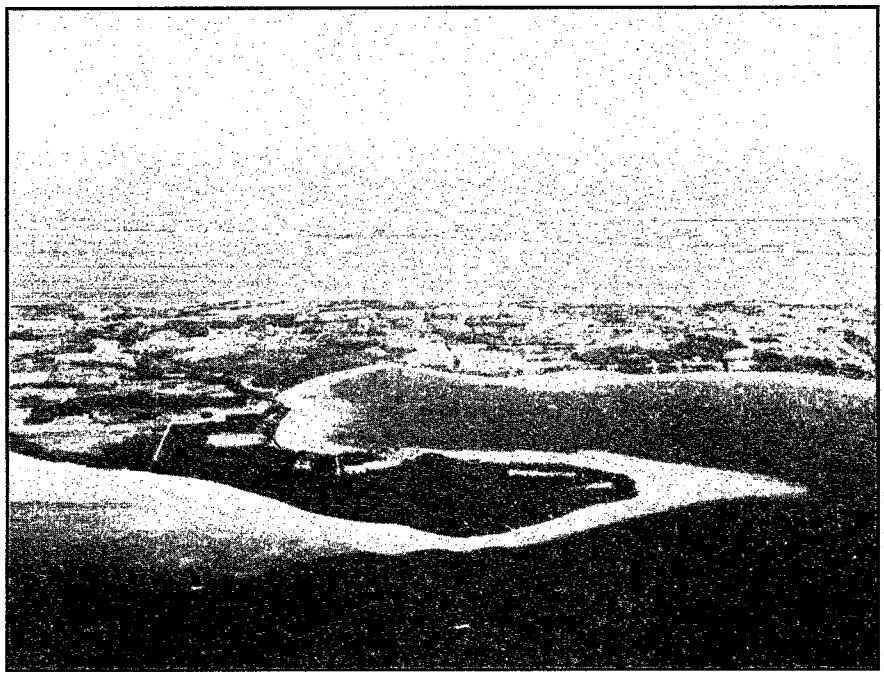


Photo courtesy of Ted Cline.

The Grand Traverse Bay offers spectacular views.

Initial efforts of the small group that was working to coordinate the Initiative centered around gaining recognition for this prevention-oriented approach as a priority in the Great Lakes. A successful campaign to host the International Joint Commission's (IJC) biennial meeting in Traverse City demonstrated to agencies and political leaders in Lansing, MI, and Washington, DC, that Grand Traverse Bay residents were committed to gaining status as a model for pollution prevention. This week-long event also served to strengthen the local partnership that had been building.

The Initiative is currently managed under a partnership agreement between more than 100 citizen, agency, economic development, natural resource, and local government groups who seek to balance increasing development pressures with the need to preserve the high quality resources essential to the area's tourism and recreation industries. The strong participation and broad range of interest sectors represented during the Initiative's first year demonstrated that local people felt the time had come to work together to address issues affecting the watershed. A Partnership Steering Committee, comprised of representatives from each of the signing organizations, meets on a quarterly basis and continues to be the decision-making body. Meetings of the Partnership Steering Committee have typically attracted 40 to 60 people representing the partner organizations. In the early Steering Committee meetings, consensus was reached on a vision statement and five specific goals that would drive the Initiative's future. Standing subcommittees have recently formed to pursue action items needed to meet each goal (Figure 1).

Grand Traverse Bay Watershed Initiative Vision and Goals

"The ecological integrity of the Grand Traverse Bay Watershed will be sustained or restored to ensure regional economic viability and quality use by future generations."

Goal #1: Identify water quality and other resource problems in the watershed and restore the environment where possible.

Goal #2: Create a computer model to simulate and/or predict ecological results of watershed activities.

Goal #3: People in the watershed are knowledgeable of their link to the area's environment and take responsibility for their actions.

Goal #4: Local units of governments make well informed decisions which consider regional impacts on water quality and other resources.

Goal #5: Develop, implement, and enhance conservation programs focused on protecting land and other resources within the watershed.

Figure 1. Grand Traverse Bay Watershed Initiative vision and goals.

The Grand Traverse Bay Watershed Initiative has been largely supported by the grass-roots efforts of local volunteers. The coordinating function has been filled during the initial phases by a 10-member Task Force led by the Northwest Michigan Resource Conservation and Development (RC&D) Council, Inc. and the Northwest Michigan Council of Governments (NWMCOG). The Michigan Department of Natural Resources (DNR) Surface Water Quality Division, the Grand Traverse County Drain Commissioner, and several key agricultural, conservation, research, and educational organizations are represented on the Task Force. In addition to the large local partnership representation, several key Great Lakes organizations, including the Great Lakes Commission and the Center for the Great Lakes, have signed the Grand Traverse Bay Watershed Initiative Partnership Agreement. (See list of Partnership members in Figure 2.) These organizations, along with the IJC, serve a clearinghouse function to disseminate the Initiative's learning experiences to other watersheds and resource areas in the Great Lakes basin. The Grand Traverse Bay Watershed Initiative has been endorsed by the IJC as a model for pollution prevention in other rapidly developing Great Lakes communities:

We are extremely impressed by the community's commitment to develop a model program, and support its desire to be the first area designated as a high-quality or sustainable development area worthy of long-term protection. IJC

The Initiative continues to gain recognition as a model program. The local partnership is seen as an alternative to the agency-driven or enforcement approach commonly used elsewhere. If successful, the Grand Traverse Bay Watershed Initiative model will be especially applicable to other rapidly developing rural areas and for newly-restored resource areas of the future.

The Partnership Agreement and Process

The Northwest Michigan RC&D Council and the Michigan DNR have used

partnership agreements and other innovative techniques to solve complex resource problems in the region. A partnership agreement is defined as " . . . a concise document that unifies diverse groups around a common cause or project." (Northwest Michigan RC&D Council, Inc., 1991.) The issue of watershed resource management in the Grand Traverse Bay region was seen as a key opportunity to use a partnership agreement as a means of identifying common ground. This partnership agreement, however, was likely to be extremely large, due to the large land area, number of local jurisdictions, and the diverse interests—from agriculture, hunting, and fishing to tourism and commercial development—represented in the watershed.

A partnership agreement was drafted in 1991 by the Initiative Task Force members (Figure 3). This document set forth the *basic values* and principles that would serve as the common ground between the partners. The document itself simply reaffirmed those concepts that most interested groups already believed: the high-quality natural resources of the watershed region were critical to its ecological and economic future and therefore must be maintained, protected, or restored. Most importantly, the Partnership Agreement set the tone of "*balance*" between economic growth and ecological integrity, establishing early on that the Initiative would not adopt a confrontational, "no-growth" philosophy.

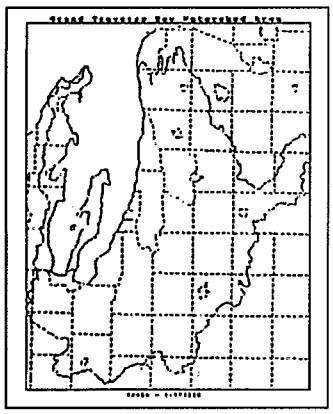
GRAND TRAVERSE BAY WATERSHED INITIATIVE PARTNERS
(Updated February 24, 1993)

Acme Township
Antrim Soil and Water Conservation District
Antrim County Cooperative Extension Service
AuSable Institute of Environmental Studies
Banks Township
Belanger Creek Watershed Neighbors Network
Bellaire Public Schools
Bingham Township
Blair Township
Boardman Township
Central Lake Township
Central Lake Public Schools
Charlevoix County Planning Commission
Charlevoix County Soil Conservation District
Charter Township of Elmwood
Citizens for Regional Solutions
City of Traverse City
District Health Department #3 (Charlevoix)
East Bay Township
Elk Rapids Schools
Elk-Skegmog Lake Association
Forest Area Community Schools
Forest Home Township
Garfield Charter Township
Grand Traverse County Planning Commission
Grand Traverse Soil and Water Conservation District
Grand Traverse County Road Commission
Grand Traverse County Health Department
Grand Traverse County Cooperative Extension Service
Grand Traverse County Solid Waste
Grand Traverse Fruit Growers Council
Grand Traverse Regional Land Conservancy
Grand Traverse County Drain Commissioner
Grand Traverse County Soil Conservation Service
Grand Traverse Yacht Club
Grand Valley State University
Great Lakes Commission
Great Lakes Environmental Center
Helena Township
Home Builders Association of the GT Area, Inc.
Inland Seas Education Association
Kalkaska Soil and Water Conservation District
Kalkaska County Road Commission
Kalkaska County Board of Commissioners
Kalkaska County Drain Commissioner
Kalkaska County Farm Bureau
Kalkaska County Health Department
Kalkaska Public Schools
Kearney Township
Kingsley Area Schools
Lake County Gazette
League of Women Voters
Leelanau County Board of Commissioners
Leelanau MSU Extension
Leelanau Soil and Water Conservation District
Leelanau County Planning Commission
Leelanau County Health Department
Leelanau Conservancy
Leelanau County Extension Service
Leelanau County Road Commission
Leelanau County Drain Commissioner
Leland Township
Long Lake Township
Michigan Department of Commerce
Michigan Department of Natural Resources
Michigan Senator George McManus Jr.
Michigan State University Cooperative Extension/Sea Grant
Michigan State University Extension Service
Michigan Department of Agriculture
Michigan Farmer Magazine
Michigan Farm Bureau
Michigan Department of Transportation
Michigan Golf Associates
Milton Township
Neahtawanta Research and Education
Northern Michigan Environmental Action Council
Northport Public Schools
Northport Sportsmen's Club
Northwest Michigan Council of Governments
Northwest Michigan RC&D Council
Northwestern Michigan College
Norwood Township
Old Mission Conservancy
Operations Management International, Inc.
Peninsula Township
Rotary Club of Traverse City
Saginaw Basin Alliance
Suttons Bay Public Schools
Suttons Bay Township
Suttons Bay Village
The Center for the Great Lakes
Three Lakes Association
Tip of the Mitt Watershed Council
Torch Lake Township
Traverse City Area Chamber of Commerce
Traverse City Area Public Schools
Traverse Bay Area Intermediate School District
Traverse Bay Economic Development Cooperation
Traverse City Board of Realtors
Traverse Area Arts Council
Traverse City Education Association
Traverse City Light and Power
Union Township
U.S. Coast Guard Auxiliary
U.S. Coast Guard Water Resources Division
United States Congressman Bart Stupak
United States Fish and Wildlife Service
United States Senator Donald Riegle, Jr.
USDA, Farmers Home Administration
USDA, Soil Conservation Service
Village of Mancelona
Village of Elk Rapids
Village of Northport
Whitewater Township

Figure 2. Grand Traverse Bay Watershed Initiative partners.

Initial signatures were solicited through direct mailings. A personalized letter explained that the partnership agreement was not legally or financially binding, indicating that signatories would be represented on a Partnership Agreement Steering Committee that would ultimately define the direction taken by the Initiative. Initial response was tremendous; by early 1992 more than 60 organizations had signed the agreement. The Task Force subsequently targeted additional groups that were felt to be critical to the "balance" (e.g., growers associations,

The Grand Traverse Bay Watershed Initiative:
Protecting Our Quality Resources For Future Generations
PARTNERSHIP AGREEMENT



This document serves as a partnership agreement between various units of government, education, economic development groups, special interest groups and private sector organizations interested in the future of the Grand Traverse Bay Watershed region.

The parties committed to this partnership are united by a mutual concern for the protection of the integrity of the Grand Traverse Bay Watershed for quality use by future generations. The parties recognize that the region's future quality of life and economic health are dependent on the maintenance and sustainability of the natural resources of the Grand Traverse Bay Watershed.

Vision Statement: *The integrity of the Grand Traverse Bay Watershed will be sustained (or restored) for quality use by future generations.*

Background

Grand Traverse Bay is a unique resource to the Great Lakes and to the State of Michigan. The Bay is unique because it is one of the few remaining Great Lakes bays which exist in a relatively unpolluted condition. The Bay has 132 miles of shoreline, is over 600 feet deep in the East Arm, and contains 39 species of fish. The Grand Traverse Bay Watershed encompasses approximately 973 square miles and includes parts of five counties (Grand Traverse, Antrim, Leelanau, Kalkaska, & Charlevoix). The Bay can also be viewed as a model of the whole of Lake Michigan (having a populated urban area at its southern end).

Proposed Action

We the undersigned, considering the best interest of the water, natural resources, and the future development of the region, mutually agree to fully cooperate and to provide technical and financial assistance, as available, to support the multi-year Grand Traverse Bay Watershed Initiative. Coordination of the Initiative will be accomplished jointly through the Grand Traverse Bay Watershed Initiative Steering Committee, comprised of members signing this partnership agreement.

Figure 3. Grand Traverse Bay Watershed Initiative Partnership Agreement.

economic development groups, road commissions). A second recruiting effort in late 1992 targeted changeover in government representatives after elections, several missing local government units, and wider participation by chambers of commerce and special interest groups, such as sporting groups and clubs. By early 1993, the Partnership Agreement Steering Committee included more than 100 organizations.

Although the Partnership Agreement is not binding, the process tends to instill a significant sense of commitment, and perhaps peer pressure. In many cases a school district, for example, has been more willing to sign the agreement or participate in a project when they are shown that other districts in the watershed have done the same.

The Partnership Agreement process currently involves quarterly meetings. Over the course of the first three meetings, the Steering Committee reached consensus on the vision statement and five major goals that would drive the Initiative's future (Figure 1). Recent meetings have included report-back sessions from each of five standing subcommittees that have formed to address the Initiative's goals. Typically a natural resource or economic development project is featured at each quarterly meeting. The partnership process has helped instill a regional cooperative spirit between the mostly local organizations involved. The extensive Steering Committee membership has paid off in numerous instances where overlapping projects and grant proposals have been consolidated or information has been shared, simply by virtue of the communications link provided by the Initiative. The partners also have a periodic reminder that the decisions they are making in their own jurisdictions have an impact on other parts of the watershed. The Partnership itself provides a strength in numbers that is critical to levering technical, political, and financial assistance. Grant funding and agency staff resources have been more readily available where there is such a broad and clear consensus on needs, much more so

than when fragmented, independent organizations request the support.

The Grand Traverse Bay region is fortunate to have a vastly talented and experienced population, and the Initiative efforts tap this resource regularly. Slowly, the Partnership Agreement process has brought forth lay public leaders, who have volunteered to chair task forces or projects and to deliver status reports back to the larger Steering Committee. There is often a natural hesitation in this process, a tendency on the part of the groups to cling to the established leadership structure (in this case, the Task Force agencies). But given time and support, the lay public leaders develop confidence to lead meetings, deal with conflicts, and learn how to call in technical and financial assistance, as needed, from the region's established agencies or organizations. This is the "empowerment" part of the partnership agreement process. On smaller projects in the past, and hopefully on the Grand Traverse Bay Watershed Initiative, the end result is a locally-owned and locally-driven resource management coalition or system that effectively utilizes government and agency assistance as needed, rather than taking direction "from the top down."

The Successes

It has proven critical in the very large, long-term Grand Traverse Bay Watershed Initiative to constantly remind the partners of their successes. The Initiative's goals are 10- to 20- year goals, compared to the daily, weekly, or monthly goals most people set in their daily jobs.

Many of the early Initiative projects addressed sub-watershed plans and studies on major tributaries to the Grand Traverse Bay. These projects emphasized best management practices to reduce nonpoint source pollution and involved the public, watershed landowners in particular, in the solutions. Another early success of the Initiative, credited to the grass-roots efforts of a small town, was hosting the IJC's Sixth Biennial Meeting in Traverse City in September of 1991. The Initiative was featured in presentations to the attenders of this meeting. Local and national press provided excellent coverage of the Initiative's first year at a time when "sustainability" and "pollution prevention" were emerging as international priorities. Combined, these endeavors established the Grand Traverse Bay Watershed Initiative as a viable effort with solid local and state support.

In early 1992, standing subcommittees were formed to address each of the Initiative's five major goals. Subcommittee membership typically includes individuals whose "regular jobs" and/or personal interests lie in the area of the goal. Some of the subcommittees promptly went out to recruit specific technical or policy expertise, or form ad hoc work groups to accomplish interim action items. At the present time, a temporary facilitator from the original Initiative Task Force works with each subcommittee to fine-tune objectives, initiate action items, recruit additional support, and maintain communications between subcommittees. In the next year (1993), the subcommittees are likely to appoint a permanent chairperson from the public representation. Specific accomplishments of the overall Steering Committee and the subcommittees over the past year include:

- The Public Education and Awareness Subcommittee is sponsoring the first annual "Watershed Week" in April 1993 to help establish "watershed consciousness."
- The Resource Problems Subcommittee has developed lists of problem types and known problem sites and is drafting a prioritization strategy for addressing those problems.
- Various Steering Committee organizations have completed watershed management planning and implementation projects on the Boardman River, Elk River, Mitchell Creek, and Belanger Creek.
- The Conservation/Protection Subcommittee has launched a project to identify and map priority wetlands in the watershed.
- The Regulations and Structure Subcommittee is interacting with a consultant to review options and case studies that will be used by the Partnership Agreement Steering Committee to identify preferred strategies for future watershed management. At a "Management Summit" during Watershed Week '93, the Steering Committee will work through a facilitated process to reach their own consensus on what next steps should be taken.

- The Initiative Steering Committee submitted comments on the EPA's Lake Michigan Lakewide Management Plan, and has gained a position on the public input Forum group for this important process.

Current Challenges

As the Grand Traverse Bay Watershed Initiative enters its third active year, organizational, publicity, funding, and communications challenges continue to grow commensurately with the expanding partnership representation. These challenges are somewhat characteristic of a bottom-up, grassroots effort. No line organization is in place, and communications (mailings, grant coordination, meetings) are imperfect. Individual member organizations do not have large sums of cash to contribute to projects, publicity, or grant matches, while at the same time state and federal funding sources are dwindling. Perhaps most importantly, the Grand Traverse Bay Watershed Initiative feels the eyes and ears of Great Lakes and international groups upon it, waiting to see if such a large, locally-driven partnership can really succeed. There is a strong sense inside and outside the Initiative that now is the time for action, and that there may only be one chance to fulfill the vision statement of preserving the resource.

Several key actions are underway to address the current challenges. A project administered by NWMCOG and funded by the Michigan DNR has employed a consultant to assist the Partnership Steering Committee to plan for the future watershed management organization. Under this institutional analysis, various legal and financial options, relevant case studies, and existing organizations will be examined and presented to the Partnership Steering Committee as options for managing the watershed in the future. In this way, the local Partnership members themselves will drive the important decisions affecting the future of the region's watershed.

A recent proposal sponsored by the Northwest Michigan RC&D Council seeks private foundation funding to institutionalize the Initiative over a two-year period. A full-time watershed coordinator would be employed over this period to provide a communications and publicity point of contact and to maintain the Partnership Agreement process (i.e., meetings, subcommittee projects, membership). The same individual would implement the preferred options identified in the Institutional Analysis project, positioning the Initiative to become self-sufficient at the end of the interim period.

The Task Force and other members of the Steering Committee are committed to maintaining progress on the priority actions identified under the Initiative's goals. Individual organizations and collaborative teams continue to pursue research, inventory, public outreach, and conservation projects with increasing success. As new members continue to join the Partnership, existing representatives meet with them to identify areas of common interest that will tend to increase the efficiency and likelihood of support for the priority projects.

Financially, there is an increased emphasis on the value of individual organizations' contributions. Steering Committee member organizations are confident enough in the benefits of achieving the Initiative's goals that their staff are able to specifically allocate time to participate on Subcommittees and in Partnership meetings. Organizations such as the Grand Traverse County Planning Commission, the Michigan DNR, and regional land conservancies have been willing to donate staff time, equipment, facilities, and hard dollars to the Initiative's projects. The sum of these contributions adds up to a substantial value that is critical in levering additional "outside" funding from public or private sources. In addition, available funding is going farther in each project with the enhanced sharing of information and resources. For example, land owner handbooks and watershed signs designed for a recent project on Mitchell Creek can literally be duplicated for use on several additional sub-watersheds.

Future Challenges

Future funding of the Initiative presents the most significant challenge, as well as the greatest opportunity for demonstrating a model approach to benefit other regional resource managers. Recent experiences with other local partnerships for resource management suggest that creative, nontraditional and non public funding will be needed to sustain the Initiative over time. This may involve establishing a trust fund, memberships, or even a for-profit financial

basis. Options for organizational format of the Initiative will also be considered. The Partnership Agreement Steering Committee may elect to operate under the current arrangement, relying on cooperation between existing organizations, or may decide that a new public agency or private coalition is appropriate.

Certain requirements can be anticipated. The future arrangement must accommodate political and regulatory change, and still be able to maintain forward progress on the Initiative's goals. Also, the regional nature of the watershed resources will require that diverse interests and a large number of local jurisdictions (townships, counties, villages, school districts) all have a voice in and responsibility for resource management. Most importantly, the organizational, legal, and financial strategy for watershed management must be a decision of the local partners.

The Grand Traverse Bay Watershed Initiative truly serves as a model, with local citizens taking ownership and accountability for managing an important and complex natural resource. Institutional arrangements to date have centered around problem identification and restoration activities, and have struggled to involve the local public. In contrast, the Grand Traverse Bay Watershed Initiative was begun and seeks to remain a locally-driven process for managing regional resources through protection and prevention.

References

Battelle Great Lakes Environmental Center. 1992. *Final report for the Grand Traverse Bay Initiative: Part II, water quality of the Bay and tributaries.*

Northwest Michigan Resource Conservation and Development Council, Inc. 1991. *Developing partnership agreements, a process to resolve resource management issues in the 1990's.* Handbook produced in cooperation with Michigan State University Cooperative Extension Service, funded by the W.K. Kellogg Foundation.

Public Survey and Pollutant Model For Prince George's County

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Prince George's County, Landover, MD
Alan Cavacas, P.E., Manager, and Mohammed Lahlou, Senior Engineer
Environmental and Water Resources, Tetra Tech, Inc., Fairfax, VA

Prince George's County's nonpoint source public outreach program is intended to give residents an awareness of water quality problems in their neighborhood. The program focuses on teaching residents how they can make minor changes in their behavior to reduce the amount of pollutants getting into their streams. Motivational factors unique to the Kettering community were targeted to maximize public involvement.

The program is being currently implemented on a pilot scale in the Kettering watershed. The Kettering watershed houses approximately 2,800 residents, is about 20 years old, and was constructed without water quality controls. The public education program in the Kettering neighborhood utilized a public survey, in part, to assess how effective public involvement may be toward reducing nonpoint sources of pollution. This activity, coupled with a water quality model, was designed to measure the success of the public outreach program.

Public Survey

A public survey was developed and administered to all residents in the Kettering watershed. The purpose of the survey was threefold:

1. The survey acted as a tool to measure the level of environmental awareness of the community residents.
2. The survey was used to determine the extent to which community residents engaged in daily activities affecting nonpoint source pollution.
3. The survey helped determine how the community perceived the project.

Additionally, the public survey helped identify the target audience, identify special cultural communication needs, and most importantly, identify key motivators.

The survey asked questions about specific pollutants, their affect on water quality, and how the county's environmental programs could be used to minimized these pollutants. The questions on lawn and car care practices were included to gain an estimate of the amounts of fertilizers, pesticides, detergents, oil, grease, and antifreeze being applied or discharged throughout the watershed. Questions regarding current programs such as recycling, household hazardous waste collection, and reporting pollution problems were intended to provide an indication of the level of community knowledge regarding water pollution issues.

Results

Out of 1,125 households surveyed, 403 or 36 percent were returned by early September. This response rate was quite high compared with similar public survey efforts by the county's Office of Recycling, and the Chesapeake Bay Foundation. Due to the large response rate, it was assumed that the results were representative of the watershed and community as a whole. Figure 1 illustrates the survey response summaries.

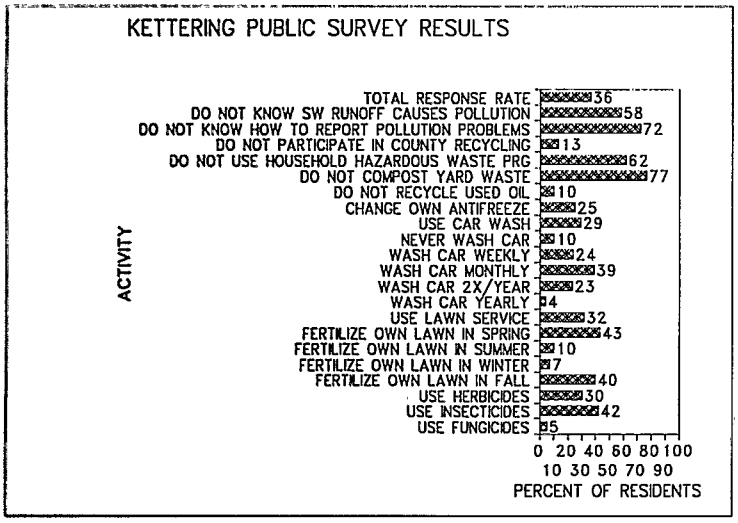

Figure 1. Public survey results.

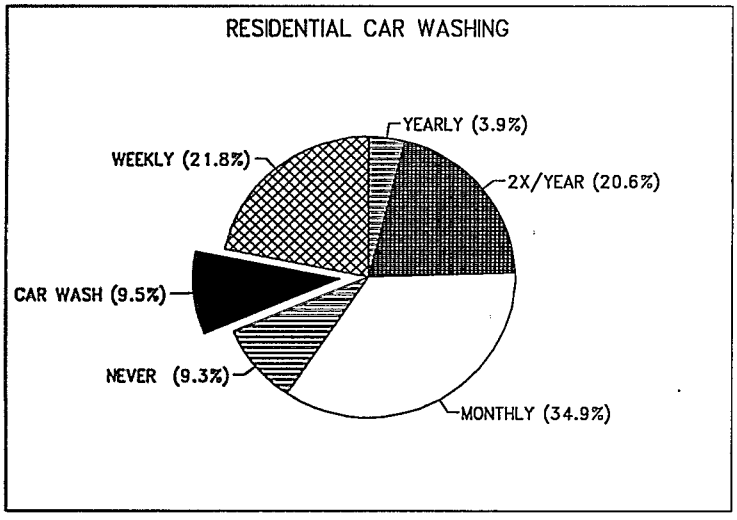

Figure 2. Residential car washing.

Discussion

General Knowledge and Participation

The initial public survey results revealed that Kettering residents lacked a general knowledge and awareness of basic nonpoint source water quality issues. Fifty-eight percent of the residents did not know storm water runoff from residential neighborhoods causes water pollution. An alarming 72 percent of the Kettering residents did not know how to report illegal dumping or other pollution problems to local officials.

Participation levels in various widely publicized county environmental programs were also low. Although 72 percent of the residents were aware of the county's household hazardous waste collection program, only 38 percent of the residents used it. In addition, although 87 percent of the residents participate in the county's curbside recycling program, only 23 percent of the residents followed the county's yard waste composting program. These composting participation levels compare favorably with 1992 national survey results, which showed an estimated 18 percent of Americans compost yard waste (Allen et al., 1992).

Automobile Care

The public survey responses on residential automobile care provided considerable insight into the pollution potential of this type of activity. Approximately 32 percent of the residents in the Kettering community change their own car oil compared to a national estimate of 25 percent (MSSCC, 1987). The survey showed that an overwhelming 90 percent of the Kettering residents who change their own car oil recycle it. However, 10 percent of the used oil is still being disposed of improperly. It has the potential to cause environmental damage.

Similarly, 25 percent of Kettering residents change their own antifreeze. Antifreeze is a highly toxic household chemical containing ethylene glycol. It is estimated that all of the used antifreeze from this neighborhood contaminates storm drain systems and nearby waterways through dumping and discharges.

Residential car washing primarily occurs on impervious areas where detergent-laden water discharges directly to nearby storm drain systems. Other studies (Pitt, 1990) indicate that residential car washing can be a major contributor to detergents entering nearby stream systems. Detergents contain high levels of phosphorus and other pollutants potentially toxic to the aquatic system. In spite of this hazard, little information is available to educate the public on how this daily activity can become a major source of nonpoint source pollution to nearby stream systems.

Figure 2 illustrates the distribution of residential car washing activity throughout the Kettering community. The majority of Kettering residents, or 57 percent, wash their car one to four times a month. Only 10 percent prefer using a commercial car wash.

Lawn Care

Americans spend an estimated $6 billion a year to obtain the greenest lawn possible (Rutgers, 1992). Kettering single-family residents are among these "green lawn" enthusiasts. Survey results show that approximately 87 percent of all of the residents apply fertilizers to their lawn, and 80 percent use pesticides. In spite of these efforts, approximately 49 percent are not satisfied with the appearance of their lawn.

Figure 3 describes fertilizer applications for the single-family residents in the Kettering community who do not use a lawn care service. The majority of fertilizer applications occur in the spring and fall. Applying fertilizers in the spring can increase irrigation needs, mowing requirements, and may weaken grass roots. The Maryland Cooperative Extension Service has developed an environmentally sensitive, low cost lawn care program which recommends restricting fertilizer applications to the fall only (Stewart, 1982). Figure 4 illustrates that only 11 percent of the Kettering single-family residents currently follow this fertilizer application program.

Figure 5 describes pesticide usage by single-family residents who do not use a lawn care service. Our public education program proposed options that would reduce the percentage of homeowners who use pesticides by recommending using pesticides only on an identified problem.

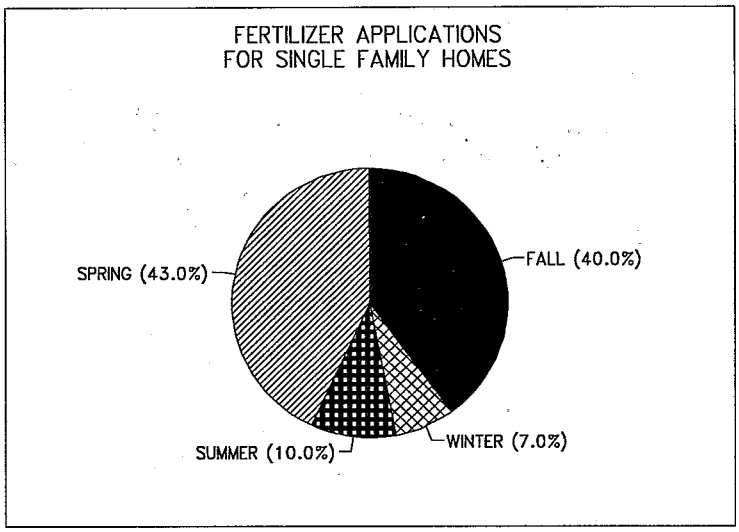

Figure 3. Fertilizer applications.

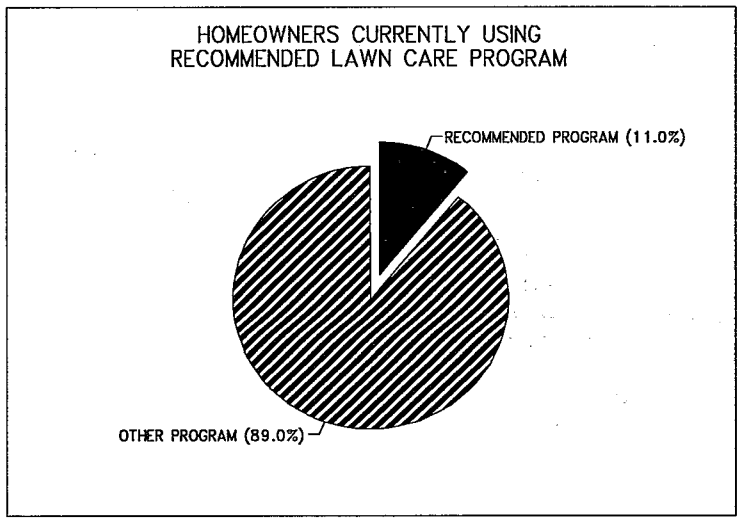

Figure 4. Recommended lawn care program users.

Pollutant Load Model

The results of the public survey were combined with the results of the field reconnaissance study and information gathered from the Cooperative Extension Service and garden centers to estimate the potential application of chemicals within the watershed. The estimates were generated with simple mathematical expressions which determine the quantity of chemicals based on average homeowner application rates. The data generated was used to make informed decisions regarding how water quality improvement programs should be tailored to be most effective for this particular community . The pollutants studied included total nitrogen, total phosphorus, detergents, motor oil, and antifreeze.

Table 1 illustrates general watershed characteristics and chemical application rates. Table 2 lists the mathematical

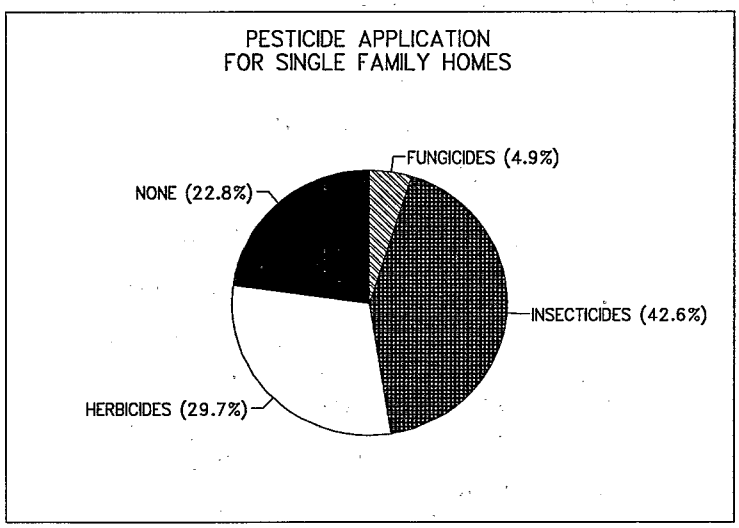

Figure 5. Pesticides.

Table 1. Model input parameters

	Amount				Rate
	Fall	Winter	Spring	Summer	
Single Family					
Nitrogen	3 lb/1000 ft²	2 lb/1000 ft²	3 lb/1000 ft²	3 lb/1000 ft²	
Phosphorus	6 lb/1000 ft²	4 lb/1000 ft²	6 lb/1000 ft²	6 lb/1000 ft²	
Townhouse					
Nitrogen	5 lb/1000 ft² applied evenly throughout the year				
Phosphorus	10 lb/1000 ft² applied evenly throughout the year				
All Owners					
Detergents					1/8 cup/wash
Motor Oil	4 quarts per car per change				4 x/year
Antifreeze	4 quarts per car per change				2 x/year

Land Use:
Residential = 256.31 acres
Commercial = 21.66 acres
Open Space = 83.03 acres
Single Family = 965

Dwelling Units:
Townhouse = 160
Townhouse lawn area: 387,000 ft²
Single family lawn area: 5,000 ft²

Table 2. Pollutant load expressions

Nitrogen	$Y_n = [L(N_s a_s + N_f a_f + N_w a_w + N_p a_p) + L_t a_t]/1000$
Phosphorus	$Y_p = r[(L)(N_s a_s + N_f a_f + N_w a_w + N_p a_p) + (L_t a_t)]/1000$
Motor Oil	$Y_o = (x)(n)(P)(f)(a)(1 - R)$
Antifreeze	$Y_a = (x)(n)(P)(f)(a)(1 - R)$
Detergents	$Y_d = (x)(n)[P_1 f_1 + P_2 f_2 + P_3 f_3 + P_4 f_4](a)(1 - R)$

Where:

Y = total amount of pollutant applied per year (lb or quarts)
x = number of cars per dwelling unit
n = total number of dwelling units
N = number of applications
P = participation of residents in activity (%)
a = amount of pollutant per application (lb/1000 ft² or quarts)
f = frequency of participation
R = participation in recycling (%)
L = lawn size for single family residents (ft²)
L_t = lawn size for townhouse (ft²)
r = ratio of phosphorus to nitrogen in fertilizer

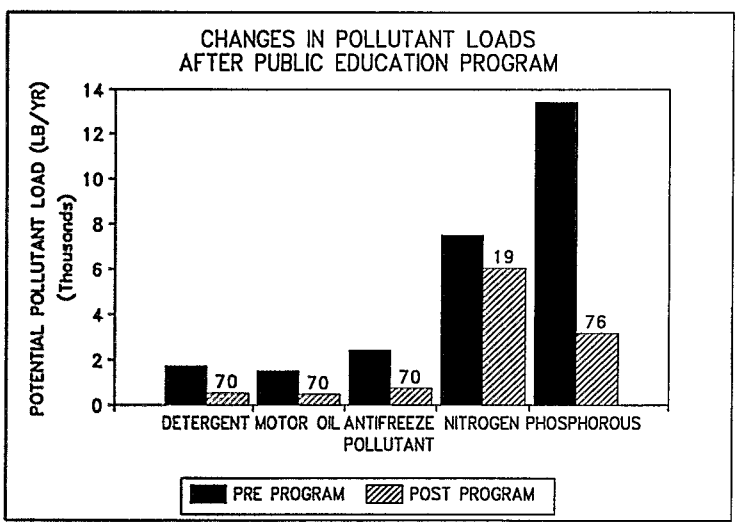

Figure 6. Predicted changes in applications.

expressions used to compute the estimated applied pollutant load. Figure 6 illustrates the estimated load of pollutants applied per year in the Kettering watershed for total nitrogen, total phosphorus, detergents, motor oil, and antifreeze.

Discussion

Application Rates

The pollutant application estimates indicate relatively high amounts of nitrogen and phosphorus applications in the Kettering watershed. Although these estimates are conservative, they only reflect residential fertilizer applications. Additional sources of nitrogen and phosphorus present in the watershed may

increase these numbers. The estimated amount of detergents, antifreeze, and motor oil are alarming. Approximately 1,496 quarts of motor oil and 2,413 quarts of antifreeze are improperly disposed of each year in the Kettering watershed. These numbers pointed to a need to focus our source reduction programs for automotive fluids. Although the Kettering application estimates appear to be very high, they do not take into account such hydrologic and watershed characteristics as soils, infiltration, rainfall runoff, and time of concentration.

Figure 6 illustrates estimated potential reductions in applications using the mathematical expressions, assuming a 70 percent participation in our public outreach program. There is a direct correlation with pollutant reductions for motor oil, detergents, and antifreeze due to the nature of their application. Therefore, public education programs focusing on these pollutants may dramatically reduce their concentrations in nearby stream systems. As nitrogen and phosphorous loading rates depend on watershed characteristics not considered in the simple spreadsheet model, their concentrations in nearby stream systems may be further reduced by infiltration, nutrient uptake, evaporation, etc.

Assessing Benefits—Water Quality Model

Water quality modeling was used to evaluate pollutant washoff reductions based on application rates collected from the public survey and representative of existing conditions and anticipated post education program conditions. The results presented will be focused on nutrient reductions in residential areas based on anticipated benefits from lawn care educational programs. Specific benefits evaluated with the model include reductions in application rates and shifting application periods from spring to fall. Due to seasonal application interests and the importance of storm size and hydrology on nutrient washoff, a continuous simulation model was selected to provide insight on the potential benefits of the public education program.

The Hydrologic Simulation Program—Fortran (HSPF) continuous simulation water quality model (USEPA, 1983) was used to represent the fate and transport of pollutants in the Kettering watershed. The model will be used to simulate how nutrients originating from residential lawns, based on practices documented by the public survey, will be transported through overland and soil infiltration pathways to ultimately enter a waterbody. The model will be calibrated to monitoring data for several pollutants and flow over the next year; however, at this point it has been adjusted to literature values and available data in the County (Tetra Tech, 1993).

The modeling of phosphorus and nitrogen runoff was performed to predict the annual, seasonal, and monthly reductions in pollutant loads. Seasonal and monthly load reductions are important as program initiatives may be directed to reduce pollutant loads during critical spring and summer periods. Spring and summer represent critical periods for spawning. In addition, spring and summer storms have higher pollutant transport capacity allowing a greater percent of nutrients from lawn fertilizers to make its way to the receiving waterbody.

To demonstrate how managing fertilizer applications can reduce watershed pollutant loads, an assessment of conditions before and predicted conditions after the public education program was performed using the HSPF model. Figure 7 identifies how the educational program regarding lawn care, which assumes 70 percent participation, will reduce mean monthly nitrogen concentrations downstream of residential areas. The variation in application rates and seasonal distribution used in the HSPF model is also shown in Figure 8.

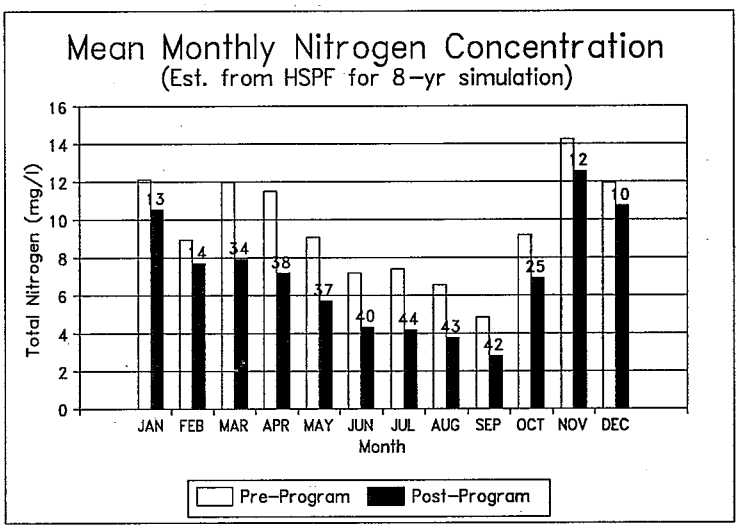

Figure 7. Nitrogen concentrations.

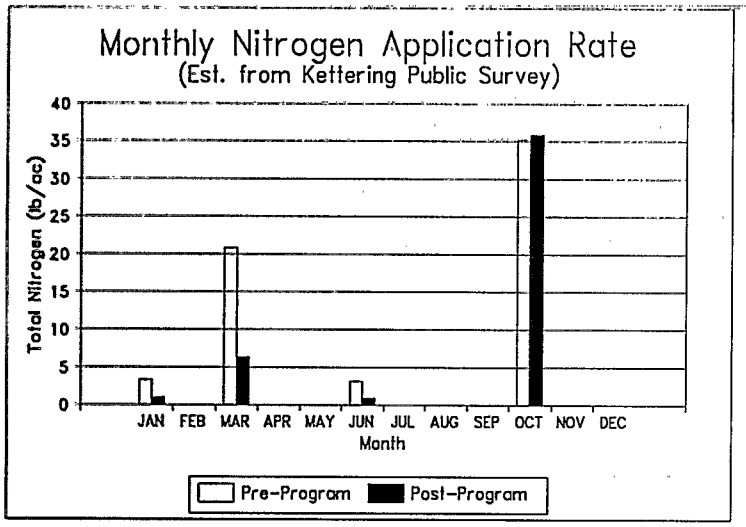

Figure 8. Nitrogen application rates.

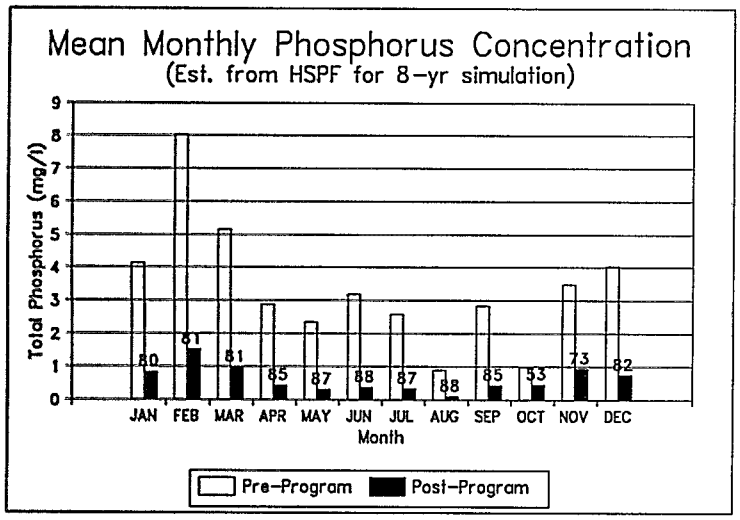

Figure 9. Phosphorus concentration.

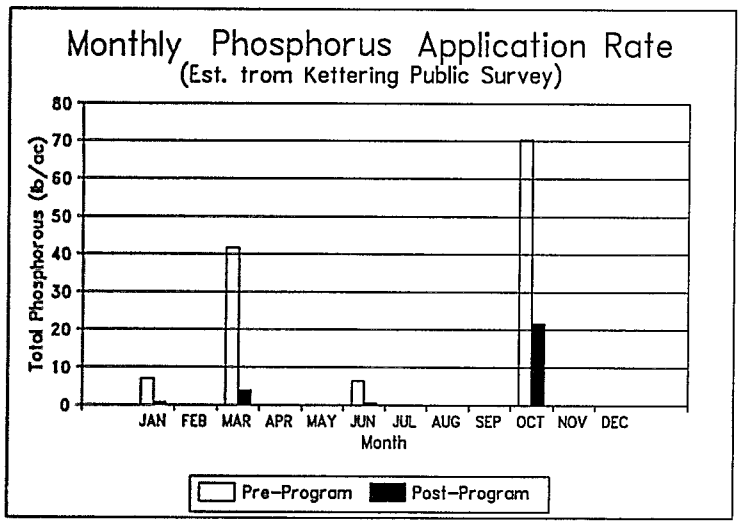

Figure 10. Phosphorus application rates.

These data are based on simulating an 8-year period of historic hydrologic conditions. Mean total phosphorous concentrations (Figure 9) are also significantly reduced. Nitrogen reduction is less significant partly due to the high mobility of nitrogen and the lower reduction in application rates proposed in the education program. It is important to note, however, that the seasonal reductions in nitrogen are greater in the spring/summer period due to the timing shift of fertilizer applications from spring to fall. This seasonal shift alone may yield significant ecological benefits.

The preliminary HSPF results indicate that a 78 percent reduction in phosphorus application rates would be further reduced to 82 percent when considering the fate and transport losses and seasonal displacement of nutrient application from spring to fall (Figure 10). Because phosphorus is highly adsorbed to sediment particles, it has a higher likelihood to be removed in transport to the stream. However nitrogen is more likely to transport through the system, which is why a 29 percent application rate reduction did not exhibit further reductions due to fate and transport losses.

Conclusions

The public survey acted as a catalyst for getting the community residents involved in the project from the beginning. Their responses helped us to tailor the public outreach program by determining the community educational and environmental needs.

Although a few public surveys on water polluting activities have been published, little has been done to quantify the survey results into actual pollutant runoff. Using the public survey results, the pollutant loading estimates provide baseline data which quantitatively describe the nature and scope of nonpoint pollution sources in the Kettering watershed. The data generated are very useful in targeting public education programs. The methods used were simple and relatively inexpensive, and provide an ideal alternative to extensive, costly, and difficult water quality monitoring.

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The Missouri SALT Program: Local People Solving Local Problems

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Missouri has very diverse natural and agricultural resources and as a result the soil and water conservation needs also vary. The Missouri Soil and Water Districts Commission (SWDC) is charged with addressing the soil and water conservation needs of the state. Specifically, the mission of the SWDC, with staff provided by the Soil and Water Conservation Program (SWCP) of the Department of Natural Resources, is to formulate policies and general programs for saving soil and water through Missouri's soil and water conservation districts (SWCDs). The prime goal is to effect, by the year 2000, the reduction of erosion on cropland, pasture, forestland, and rangeland in the state to "T," i.e., the amount of soil loss that may be tolerated and still maintain a high level of productivity over a long period of time. The citizens of Missouri expressed their commitment to the goal by approving a parks and soil sales tax of one-tenth of a percentage. This tax makes several land assistance programs possible including the Special Area Land Treatment (SALT) Program.

SALT: Land Treatment Is the Goal

The SALT program can be defined as *a locally managed program that targets watersheds for land treatment. Land treatment* is the goal of the program. The primary goal is soil erosion control. Every project in the state has the goal that 75 percent to 80 percent of the agricultural land in the watershed identified as having a soil erosion problem receives conservation treatment by the end of the project. The life span of these projects ranges from 5 to 8 years.

In addition to the primary goal of soil erosion control, each project has its own set of goals as part of a *total resource management plan.* Improved water quality is a goal for several projects. These projects focus on reducing the threat of agricultural nonpoint source pollution to the state's pristine streams and lakes. The source of these threats may be sedimentation, nutrients, pesticides, or animal waste. For several projects, the watershed drains into a recreational or water-supply lake; therefore, improved water quality is a natural goal. In addition to improved water quality, other local goals include improvement in other land resources such as timberland or pastureland, improved wildlife habitat, or promoting sustainable agriculture practices in the project area.

SALT: Targets Watersheds

SALT seeks to achieve the goal of land treatment by *targeting small manageable areas and those areas are watersheds.* The program makes use of the targeting mechanism to focus on well-defined land resource problems. As stated earlier, Missouri is a very diverse state. There are different resource needs throughout the state. SALT focuses on small, manageable areas to provide specific solutions to

specific problems. With a mission of soil and water conservation, a watershed provides the SALT program a natural focusing mechanism. By focusing on watersheds, the SALT program brings together the people that affect and are affected by the watershed.

SALT: Locally Managed

Finally, SALT is a program that is *locally managed.* The administering soil and water conservation district board of supervisors is responsible for planning and organizing the activities of the project. The board is assisted by a project committee. The project committee is composed of at least four land representatives from the project area. Others can serve on the project committees. City managers, industry, and private organization representatives are examples of different individuals who have served on SALT project committees.

Program Effectiveness

The SALT program began in 1986 with four projects. Today there are over 100 SALT and EARTH projects operating across the state (Figure 1). EARTH projects began in 1990 and were added to the SALT program to address the needs of larger watersheds. The goal and administration of the EARTH projects are much the same as those of the SALT projects with the main difference being EARTH projects are allowed additional resources to address the needs of the larger watersheds. SALT project watershed areas vary from 1,000 acres to 30,000 acres, whereas EARTH project watershed areas range from 10,000 acres to 60,000 acres. Over one million acres have been enrolled in the SALT program to date, and the program is efficiently and effectively addressing the land resource needs.

The SALT program has gained recognition for its efforts, recently receiving the U.S. Environmental Protection Agency

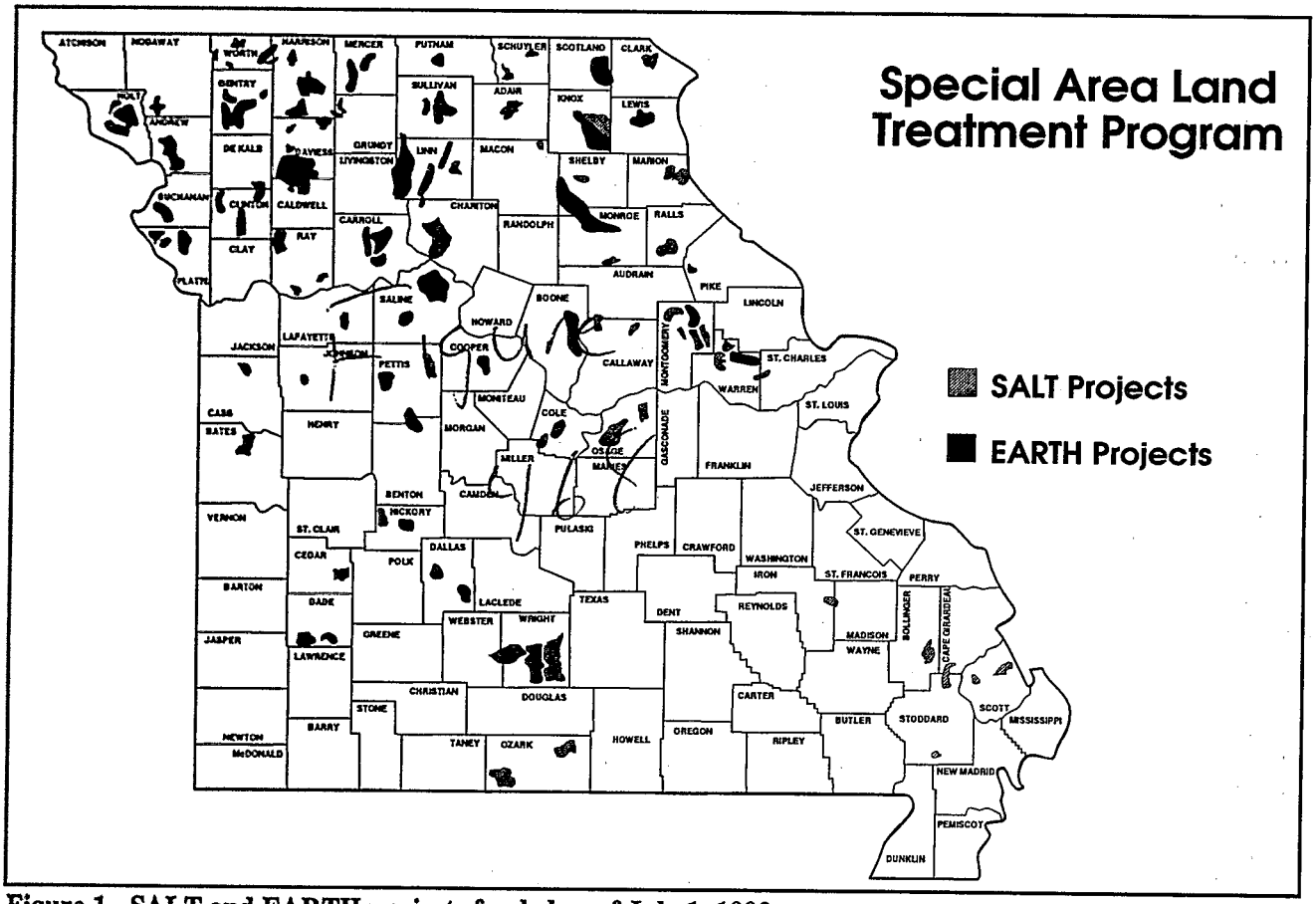

Figure 1. SALT and EARTH projects funded as of July 1, 1992.

(EPA) Region VII Regional Administrator's pollution prevention award and a certificate of environmental achievement from the national environmental awards council. Considerable attention has also been received from local, state, and national media.

The Key to Building Public Support

Perhaps the greatest success of the SALT program is in its ability to generate public support for watershed management. There are three key reasons why the SALT program enjoys such high public support (Figure 2). First *local people initiate the project.* A SALT project comes into being through local initiatives. Without local initiatives, there can be no project. With local initiative, local people have ownership of the project. Local SWCDs submit SALT project applications to the state and the applications are reviewed and approved through a competitive process. The local SWCD has to take the initiative to target a watershed area, inventory the resources and needs of the watershed area, and propose specific solutions. Also, individual landowners in the area are made aware of the proposed project and the project receives state approval only when a majority of the landowners indicate they want the project in their area and have agreed to participate.

Second, *local people determine the problems.* As discussed earlier, the primary goal of the project is the control of soil erosion. However, due to the diverse nature of the resources across the state, all projects have a variety of resource problems to address. The local SWCD's watershed landowners and community leaders work together to determine the problems that they face in their particular area. In this process, these people become intimately aware of the problems and have a personal stake in seeing these problems addressed.

Finally, *local people determine the solutions.* Once the problems facing the area are known, solutions to address the problems must be decided upon. The local people managing the project are afforded a great degree of flexibility in planning and implementing solutions to the problems identified. Several different resources are available including cost-share to landowners for installing conservation practices and loan-interest share to reimburse landowners for a portion of the interest on loans for conservation equipment or practices. In addition, the state provides an annual grant to the administering SWCD to support the project. This grant may be used for items such as personnel to provide the project technical assistance, for the purchase of field, office, or technical equipment, or for information/education programs. Examples of such information/education programs include field days, tours, and demonstrations of innovative conservation practices for project participants. Allowing the local people to decide how to address the problems *they* have identified generates a much greater sense of local responsibility for the success of the project.

Individual Projects

Each of the over 100 projects across the state is unique. In what follows, several projects are presented which especially represent the total resource management planning being done by the local people administering the project.

Knox SWCD: Troublesome Creek EARTH Project

The Troublesome Creek EARTH Project is located in a 23,000-acre watershed in northeast Missouri and serves as an

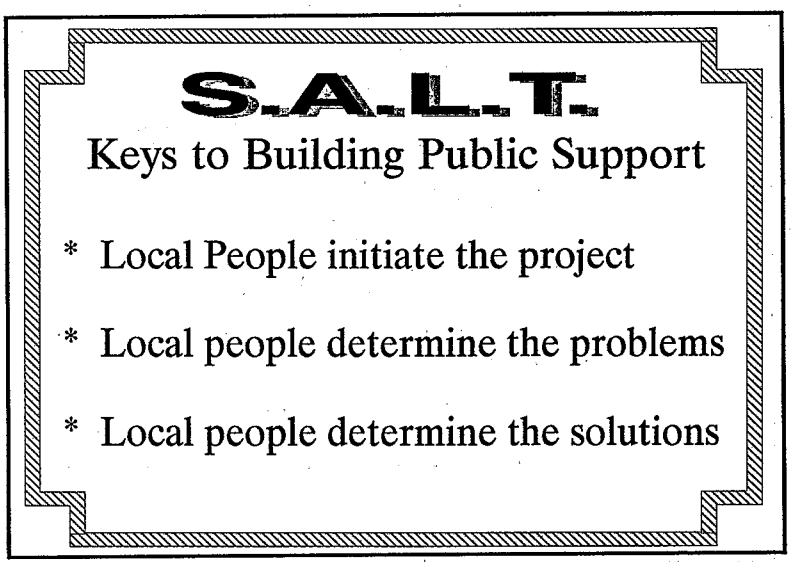

Figure 2. Keys to building public support.

example of a project that has identified multiple goals. Control of sheet, rill, and gully erosion is a primary concern. In addition, the district wants to improve the productivity of the woodlands, pastureland, and wildlife habitat. To improve the productivity of the area woodlands, the project is working with a local woodland support group that includes the area timber industry and U.S. Forest Service. Together, they have developed a woodland demonstration project that shows the profitability of preserving the woodlands by releasing existing silver maple trees from surrounding tree competition. The project has sponsored several tours of the demonstration area. Also, the EARTH project is working with the state's conservation department to increase the use of native warm season grass for wildlife habitat and are assisting landowners in establishing woodland edges that are productive for wildlife.

Montgomery SWCD SALT Projects

The Montgomery SWCD has developed an extensive information/education program for its SALT and EARTH projects. One specific example of a successful information/education project is a field day that was held in the Little Coon Creek SALT project. The field day began with a University of Missouri forage specialist discussing pasture management with area landowners. Afterwards, participants boarded tractor-drawn wagons and viewed the actual management practices in the field. This field day brought together in a unique way the people that managed the pasture resources in that area with an expert in pasture resource management. The field day was advertised through paper and radio and resulted in over 100 landowners attending. This SALT project field day, therefore, had an effect on the management of the pasture resources well beyond the boundaries of the SALT area.

Warren SWCD: Peruque Creek EARTH Project

The Peruque Creek EARTH Project is in a 11,300-acre watershed located in eastern Warren county with nearly 75 agricultural landowners. The outlet of the watershed flows directly into Lake St. Louis, which is a highly developed recreational lake. A major objective of this project is to reduce the amount of sediment being delivered to the lake from the watershed.

As a result of the Peruque Creek EARTH project, a unique partnership has been formed between the farmers in the watershed and the members of the lake association. Several joint meetings have been held by the project for the interested parties to discuss the problem and solutions for the problem, and to plan and prioritize those solutions.

Wright SWCD: Woodsfork SALT Project

The Woodsfork SALT project is a 6,200-acre watershed located in the south-central Ozark region of Missouri. The primary objective of the project was the improvement of pastureland in the watershed. However, the SWCD was also concerned about poor management of the animal waste from dairy operations in the watershed. Although the SALT program does not directly fund animal waste systems, the Wright SWCD used the project to organize a package of funding to support a five year project to treat animal waste problems. Several different agencies provided funds so that lagoons and containment systems could be built and pump-down and irrigation equipment could be purchased. The Woodfork SALT project was completed in December 1992, with 83 percent of the project area receiving treatment and 12 animal waste management systems installed.

Monroe SWCD: Otter Creek EARTH Project

The Otter Creek EARTH Project is located in a 67,000-acre watershed that spans three different counties. The watershed is a sub-watershed for Mark Twain Lake, a recreational and water supply lake. The primary goal for the project is the prevention of soil erosion with a secondary goal of improved water quality for Mark Twain Lake.

The project has just begun a partnership with the University of Missouri (UMC). Researchers at UMC applied and received an EPA section 319 grant to work with landowners in the Otter Creek watershed on a nonpoint source water pollution demonstration and education program. The expected results include a reduction in the use of pesticides (particularly atrazine) and fertilizers with an overall promotion of sustainable agriculture.

Summary

SALT is a unique program that has taken a novel approach to watershed management. The SALT program utilizes an extremely "bottom-up" approach, letting the local people in the watershed initiate the project, determine the problems, and implement the solutions.

State management of the SALT program through the Missouri Soil and Water Conservation Program basically occurs in three ways. First, the state is responsible for initially reviewing and approving project applications. Second, the state provides the project the financial resources for accomplishing the goals relating to soil and water conservation. The SWCD, however, is responsible for acquiring the necessary funding for any other goals. Third, the state closely monitors the progress of each project. When a project is identified as experiencing a lack of progress or "struggling," it is given extra attention from state staff to assist the local managers in identifying why the project is struggling and how to correct the situation. In some cases, projects have been canceled due to lack of progress. Overall, the success rate of individual projects has been very high. To date, nearly 95 percent of all projects initiated are successfully meeting their land treatment objectives. Local interest remains high throughout the life span of the projects because all the members of the group—the participants in the watershed area—encourage and motivate each other.

There have been obstacles along the way. Projects have suffered when they were initiated in a "top-down" manner rather than the "bottom-up" manner. This may occur, for example, when an overly enthusiastic government official "sells" the local people on starting a project. This takes away the local initiative and the local ownership. Other obstacles occur when the local people initiate the project for the wrong motives. Some projects are initiated simply for the financial grant. In these cases, the goal is not land treatment; instead, the goal is to obtain funds and thus the means become the goal.

Finally, people in SALT project watersheds realize that the natural resources in their watershed need to be protected. Although there are often many challenges involved in solving a resource management problem in a watershed, the SALT program has helped bring together the tools to meet that challenge—people, technical expertise, and funds. On the basis of its current success, it is highly likely that the SALT "concept" will continue to be used in the future to address watershed management issues.

Clean Water Strategy

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Goal

The purpose of the Clean Water Strategy is to provide a conceptual framework for the Department of Environmental Protection's (DEP) water resources programs, centered in the Bureau of Resource Protection (BRP). The overall goal of the Strategy is to protect the environmental integrity of the Commonwealth of Massachusetts' water resources by putting the necessary tools in place to set resource-based priorities, integrate programs geographically, and improve the effectiveness and efficiency of programs that cross division lines. There are three major elements of the Clean Water Strategy—river basins, geographic information systems (GIS), and improved program coordination.

River basins are the basic planning unit for focusing and integrating water resource protection programs. To the maximum extent practical, BRP's monitoring, permitting, compliance, enforcement, and public outreach programs will be coordinated within river basins, which will be examined in depth every 5 years, in accordance with the renewal schedule of major withdrawal and discharge permits. In this way, water quality and water quantity issues can be simultaneously evaluated, cumulative impacts can be better addressed, a more informed public can participate in the information gathering and decision-making process, and program efficiencies and effectiveness can be realized by planning in advance the convergence of several related activities. Pilot projects in the Stony Brook sub-basin of the Merrimack River and the Housatonic River Basin have been undertaken, which DEP will build upon in fiscal year (FY) 1994 and beyond.

GIS is the most critical management information system for establishing water resource protection priorities. GIS will be used to identify the most sensitive watersheds in the Commonwealth by overlaying water resource attributes of statewide significance. The co-occurrence of such characteristics will identify critical areas for extra protection efforts, such as stricter regulatory controls via designation of Outstanding Resource Waters or Areas of Critical Environmental Concern, or prime sites for state land acquisition. By evaluating the relationship between critical areas information in GIS and DEP's regulated facility data base, the Facility Master File (FMF), DEP can further target permitting, compliance, enforcement, and technical assistance efforts to those facilities and activities that threaten critical resource areas. The GIS/FMF interface, which will integrate these two systems, is currently under development. In addition to FMF, resource threats will be assessed using water quality data bases, the 305(b) report of statewide water quality, nonpoint source assessments (and information in the state's Nonpoint Source Management Plan), hazardous waste site locations (using sites data base), and other information systems. Thus, for each river basin and statewide, DEP can set priorities with regard to critical resource areas and those activities that pose the greatest threats and can target its programs accordingly.

In the third element of the Strategy, improved program coordination, the theme of "less process, more protection" plays out. This aspect of the Strategy borrows from the concept of Total Quality Management, which calls for continuously improving ways to effectively and efficiently deliver services. Regulatory agencies need to be sensitive to issues of procedural delay while striving to accomplish the highest level of environmental protection

possible. By operating programs efficiently, agencies can build credit and support for taking tough positions on resource protection. Improved program coordination is key to the adage "Don't give away in process what you can take away in substance." The Bureau of Resource Protection has embarked on a series of cross-program coordination projects, including transfer of the water quality certification program from the Division of Water Pollution Control to the Division of Wetlands & Waterways to consolidate two closely related and sometimes duplicative programs. In this process, certain minor activities, which should be adequately regulated under state wetlands law, are exempted from the federally-derived water quality certification program (section 401 of the Clean Water Act); other activities that may cause significant impacts are screened for compliance with the state wetlands program; and other activities, such as filling of Outstanding Resource Water wetlands, are prohibited under the authority of section 401. Thus, processing delays are eliminated for all projects, most (85 percent) of the projects get little or no section 401 review, but those projects occurring in critical areas (about 15 percent of the total) are much more strictly regulated. Similar coordination efforts are underway for the management of storm water and water supply residuals. Dredging activities will be examined in the future.

Any resource protection strategy must recognize two categories for priority setting: areas where critical resources exist and must be protected and areas where resources have been degraded and need to be restored. Specific goals must be set for both preventative and remediation activities.

Pollution Prevention Goals

Pollution prevention as implemented under this Strategy will encompass protection of ecosystems for their full range of values, including flood prevention, wildlife habitat, and recreation as well as water quality protection and enhancement. Specific goals include:

- Water resources should be protected to ensure that the state's existing and potential public drinking water supplies do not present adverse health risks and are preserved for future generations.
- Water resources should be protected to ensure the integrity of aquatic ecosystems.
- Water resources should be protected to ensure that ground waters that are closely hydrologically connected to surface waters do not interfere with the attainment of surface water quality standards, which are necessary to protect the integrity of associated ecosystems.
- Water resources should be managed with watersheds as the basic hydrologic planning unit: water resources need to be assessed basin-wide, and regulatory actions need to be coordinated on a watershed basis (taking into account critical resource protection and restoration needs).
- Water resources protection can and should be achieved through a variety of means, including pollution prevention, source controls, siting controls, land use controls, best management practices, and land acquisition/restriction.

Remediation

Remediation activities must:

1. Minimize significant risk to human health.
2. Restore currently used and reasonably expected sources of drinking water.
3. Maintain the integrity of ecological systems. Ground water hydrologically connected to surface water resource areas should be cleaned up to meet surface water quality stan-dards for protection of aquatic life.

Given the costs and technical limitations associated with water resource remediation, DEP must take a realistic approach to restoration based on actual and reasonably expected uses of the resource. To this end, this Strategy calls for a three-tiered classification system for cleanup of ground-water resources: Safe Drinking Water Act (SDWA) standards for existing and potential drinking water supplies; surface water quality standards under the Clean Water Act (sometimes stricter than SDWA standards), in accordance with anti-degradation policy, for aquatic habitats; and less than SDWA/CWA standards for areas that do not involve releases into the above two categories. In doing so, we should strive for compatibil-

ity between ground-water and surface water standards.

Purpose

The Strategy will be used for six major purposes—protection, restoration, pollution prevention, permitting and planning, public education and outreach, and compliance and enforcement.

Protection

Critical water resource areas will be used to set priorities and target resources. The objectives are to:

- Develop a consolidated federal grants program to focus federal programs on the most important water resource problems.
- Target state grants (federal pass-through and State Revolving Fund) to address most critical water resources problems.
- Target land acquisition/restriction activities to priority resource areas.
- Direct further regulatory controls to most critical areas while decreasing process generally; for example, target extra protection efforts to most critical areas while reducing process elsewhere.

Restoration

Objectives are to:

- Identify most important resources for DEP oversight of waste site cleanup.
- Determine level of cleanup to protect water resources.
- Develop water resources restoration plans to address critical resource area enhancement where natural resource damages or other funds are available for restoration activities.

Pollution Prevention

Target such activities as pretreatment compliance and Facility-wide Inspections to Reduce the Source of Toxics (FIRST) inspections and Toxics Use Reduction efforts to priority water resource areas. Pollution threats to specific river and stream segments are identified in the 305(b) report. By identifying those facilities that discharge the offending constituents, we can better target efforts to meet water quality standards statewide. Progress can be measured in terms of improved water quality.

Permitting and Planning

Objectives are to:

- Develop watershed-based permitting to integrate surface water discharge permit renewals (e.g., National Pollutant Discharge Elimination System [NPDES]), water withdrawals under the Water Management Act, and water resources assessment/monitoring.
- Evaluate potential of developing watershed-based nonpoint source program implementation (including storm water permitting and control).
- Identify critical water resource areas to ensure consistency of statewide transportation and economic development plans with protection of statewide critical resource areas and to develop state critical areas plans.
- Assist project proponents in identifying environmental constraints of facility siting and, generally, permitting requirements of site development through the Massachusetts Environmental Policy Act (MEPA) and regional customer service centers.

Public Education and Outreach

Objectives are to:

- Identify roles of outside groups and target educational efforts (e.g., mailings, workshops, conference presentations) to state and regional nonprofits and key professional associations (e.g., attorneys, financial community, engineers, municipal officials, enforcement officials, etc.) in those areas where DEP will rely on these outside groups the most to help implement the Strategy. In particular, seek out the assistance of groups such as the Soil Conservation Service, Massachusetts Coalition of Watershed Associations, and Massachusetts Waterwatch Partnership to assist DEP in conducting basin assessments.
- Use media opportunities: press releases, develop relationships with key reporters, publicize key accomplishments of the Strategy.

- Provide technical assistance at the local municipal level.

Compliance and Enforcement

Target compliance and enforcement activities in areas where pollution threats overlap critical resources that need to be protected or restored, and coordinate compliance and enforcement activities with basin assessment and permitting.

Watershed-Based Permitting

Currently, DEP issues permits for water withdrawals, as required by Massachusetts General Law Chapter 21 (Water Management Act [WMA]), for four river basins each year, and permits are renewed every 5 years. The safe yield of each basin dictates the quantity of water available to be permitted. Reasonable instream flow is supposed to take into account ecological needs of the river basin (e.g., fisheries, wetlands) and water quality needs for such purposes as waste assimilation.

Permits for new and renewed direct surface water discharges (NPDES) are issued jointly by the U.S. Environmental Protection Agency (EPA) and DEP. Permits come up for renewal every 5 years. The amount of waste allowed to be discharged is based, in part, on the flows of the receiving water. Typically, NPDES permits acted upon each year are scattered throughout the Commonwealth; they are not issued on a watershed-by-watershed basis. As NPDES permits come up for renewal, they must meet the stricter 1990 Water Quality Standards. Unless site-specific criteria can be developed and met, existing discharges must comply with toxics limits established in the EPA "Gold Book." DEP staff have developed protocols for site-specific limits and have conducted some in-stream toxicity testing at discharge sites currently pending renewal decisions. Site-specific criteria and total maximum daily loads (TMDLs) need to be developed for entire river basins, and need to take into account point and nonpoint pollution sources.

Integrating Water Quality Surveys

By coordinating DEP's water quality assessment with DEP's water quantity analysis, essential pieces of river basin planning will be merged, which will provide more meaningful data upon which reasonable streamflow, safe yield, and water withdrawal limits can be based.

Issuing Watershed-Based NPDES and WMA Permits Simultaneously

A logical extension of coordinating water quality and water quantity data is coordinating water withdrawal permits with surface water discharge permits. The amount of water available for withdrawal from a river basin is limited, in part, by the volume necessary to assimilate discharged water. Similarly, water quality limitations for discharges must be based, in part, on the volume of the receiving water available for waste assimilation. To address issues of withdrawal and discharge limits simultaneously, all Water Management Act and NPDES permits should be issued in a given river basin at the same time. Such coordinated basin reporting and permitting would also facilitate the establishment of site-specific criteria on a river basin basis, rather than strictly on a site-by-site basis. Watershed-based criteria should save DEP staff time as well as result in more fully informed decisions.

Developing a Comprehensive Water Quality Data Base

The third, and longer-term, component of this effort is development of a comprehensive water quality data base and a compliance assessment data base. In order to provide the most comprehensive water quality assessments, and to facilitate trends analyses, it would be beneficial to access water quality data bases developed by all major state and federal agencies that conduct water quality monitoring. Issues of QA/QC, compatibility of data bases, and entry/storage/access of data need to be carefully examined. By combining monitoring data from all government sources, agencies can more specifically target their programs so that they augment rather than duplicate one another's efforts. In addition, private entities (NPDES permit holders) may be required to conduct upstream- and downstream-of-discharge monitoring, and volunteer groups can be directed to monitor needed sites and parameters to fill specific holes in the data base. This comprehensive data base can then be fed into withdrawal and discharge permit decisions.

Developing an Automated Compliance Assessment Program

Finally, compliance problems can be more effectively targeted by computerizing discharge monitoring reports that are periodically submitted to DEP for all surface and ground-water discharges. Currently, review of the monitoring reports involves time-consuming paperwork, which staff do not always find time to do. Electronic entry and analysis of the data is needed to automatically "flag" permit limit violations. At the end of the year, a report would be published, based on the analysis, showing those permittees that are in compliance with their permit limits nearly all of the time, most of the time, or only some of the time. Regulated facilities can by ranked as to their compliance record, and a "Good, Bad, and Ugly" report can help reward well-operated facilities as well as publicize records of poorly-operated ones. It is hoped that by publicizing facilities with poor compliance records, DEP can more effectively target enforcement actions and public pressure will help achieve compliance.

Setting Water Resources Priorities Using GIS

Priorities will be established in accordance with the multiple-use overlay concept, similar to the one developed by Ian McCarg. First, water resources-related attributes of statewide significance (Table 1) will be mapped on GIS and highest priority watersheds (the basic planning unit used in this Strategy) will be flagged by the greatest number and extent of attributes that are found to occur. A ranking system will be developed if needed.

Statewide implementation of the multiple-use concept in resource protection will be greatly enhanced by the completion of a statewide GIS program. This information system will allow better assessment of the relative importance of the various water resources across the Commonwealth. A high priority goal of DEP is to work with the Massachusetts Executive Office of Environmental Affairs (EOEA) to prepare a GIS plan for completing critical resource area data layers in the statewide GIS inventory (see Table 2 for list of attributes already mapped or in progress). The next step is to overlay pollution threats to those resources, some of which are mapped on GIS; others can be accessed from the FMF, which contains all DEP-permitted facilities currently under development at DEP, to GIS. The FMF-GIS interface is one of DEP's Management Information System priorities for FY93.

In addition to knowing where the greatest water resource attributes and pollution threats occur among the watersheds in Massachusetts, a certain amount of judgment is needed to match the priority resource areas with the tools that are most appropriate for protecting them. This evaluation includes such factors as: sensitivity of the resource; major pollution threats; use(s) of the resource; existing water quality and water quantity goals; the feasibility of protecting or restoring the resource; and political support for taking action. These elements are shown in the "Water Resources Impact Analysis" table, which outlines the issues to be considered in the decision-making process when it is time to match priority resource areas with appropriate protection/restoration tools. While a general GIS mapping can be developed statewide, more specific information can be added to GIS when resource assessments are conducted according to the basin permitting schedule.

Cross-Program Coordination

A number of programs which involve activities regulated by more than one Division in the Department have been identified for improved coordination. Cross-program coordination involves an analysis of existing legal structures and requirements, existing staff resources, major problems that need to be addressed, and maximum efficiencies that can be attained while meeting protection goals. Opportunities are examined for leveraging more responsibility to the private sector or other responsible parties for meeting state regulatory standards while using limited DEP resources for the most important cases and for tracking program success. These coordination activities occur both within the Bureau of Resource Protection, between Bureaus within DEP, and between state agencies. To date, the following program coordination issues have been identified and are being worked on:

- Water Quality Certification Activities for wetlands and the State Wetlands Act and regulations.

Table 1. Water use evaluation matrix (multiple use categories for prioritizing geographic areas)

Ground-Water Supply

I. Public water supply wells
   - Zone II designations

II. Sole source aquifers

III. Potential sources
   - as defined by DEP medium- and high-yield aquifers

Surface Water Supply

I. Water Supply
   A. Public reservoirs
   B. Rivers (direct withdrawal, induced infiltration)

II. Special Designations for Resource Protection
   - ACEC (Areas of Critical Environmental Concern)
   - Outstanding Resource Water (MA Surface Water Quality Standards)
   - National Wild & Scenic Rivers
   - Massachusetts Scenic Rivers and Designated Scenic Landscapes
   - Prime agricultural land (designated by Mass. Dept. of Food & Agriculture)
   - Natural valley flood storage area (designated by US Army Corps of Engineers)
   - Rare habitat

III. Fishing/Shellfishing (designated by Department of Fisheries, Wildlife, and Environmental Law Enforcement-Division of Marine Fisheries)
   - Productive, open shellfish areas
   - Productive, closed shellfish areas
   - Prime commercial fisheries
   - Prime recreational fisheries
   - Significant nurseries (salt marshes, estuaries)
   - Eel grass beds

IV. Recreation
   - National and state parks/beaches/forests
   - Prime noncontact areas (e.g., canoeing, whitewater kayaking) (designated by EOEA)
   - High-visitation private, nonprofit conservation/recreation areas

V. Waterfront Areas
   - Commonwealth Tidelands
   - State/federal waterfront parks
   - Designated Port Areas

VI. Industrial/Energy
   - Prime rivers for hydropower
   - Intensive industrial/agricultural use
   - Massachusetts historical and/or archaeological designation

- Hydrogeological reviews for ground-water discharge permits, solid waste siting, and new source approvals consolidated in one unit.
- Streamlining and coordinating storm water regulatory pr ograms under the Wetlands Act, Water Quality Certification Program, Water Pollution Control regulations, water quality standards, and federal Clean Water Act general permits.
- Management of water supply and wastewater treatment residuals under water supply, water pollution control, and solid waste regulations.
- Dredge disposal and dredging activity regulation under waterways, water pollution control, wetlands, solid waste, and hazardous waste programs.
- Cross-agency issues include regulation of forestry operations and dam safety controls.

Process and Schedule

The process for accomplishing the above goals is as follows:

- Establish a Clean Water Strategy Work Group to facilitate retreat on implementing the strategy and provide follow-up input as needed (1993).
- Recommend organizational relationships within the Bureau of Resource Protection to carry out the Strategy (1993). By reorganizing (in FY90) the Department into four Bureaus—waste prevention, resource protection, waste site cleanup, and Municipal Facilities—DEP already has a basic organizational structure in place to implement the Strategy.
- Conduct four basin assessments/basin-wide permitting efforts each year (Water Management Act, NPDES, water resources monitoring, and GIS-based resource assessment) and update data base and applicable permits at 5-year intervals; pilot

additional program likely to fit the basin approach and evaluate for full evaluation (1993+).
- Propose consolidated federal grant work plan based on the Clean Water Strategy (FY94).
- Identify and map on GIS water resource attributes of statewide significance, including inland and coastal wetlands of the Commonwealth on a scale of 1:5,000, and investigate feasibility of mapping other resource areas on the same scale and, if not, of ensuring that scales are compatible (1995).
- Identify and map on GIS, using in part the GIS/FMF interface, major sources of water pollution, existing water quality, and water quality classifications (1995).
- Implement a specific action plan for the Clean Water Strategy by assessing existing water resources protection programs to identify gaps that need to be filled through the Comprehensive Statewide Water Resources Protection Plan (1995).
- Fill the gaps by improving upon the elements laid out in this Strategy, seizing opportunities to streamline and better coordinate existing programs for more effective use of limited resources first, and only proposing new programs/regulations as a last resort and then in a way that complements existing programs (1995+).
- Plan integration with Bureau of Waste Prevention (FY94).
- Implement Waste Prevention Integration Pilot (FY95).
- Once DEP's strategy is established, begin discussions with the Water Resources Commission to facilitate a similar effort among EOEA agencies (1993-1994).
- Outreach to environmentalists, local officials, and regulated community (ongoing).
- Identify measures of success (1993-1994), develop tracking system for determining performance (1993-1994), and modify strategy as appropriate to achieve success (every 2 years).

Table 2. Summary of GIS datalayers

CURRENT MASSGIS DATALAYERS	DEP DATALAYERS STATUS
Topographic Quadrangle Template (1:25,000)	**In Progress Now**
Massachusetts State Plane Grid and Points	
Community Boundaries	Community/NC Water Supplies[a]
Community Boundaries without Coast	WS Watersheds[a]
1:25,000 Coastline	Stream Classification
Major Roads	WMA Datalayers
Road Quadrangles	Discharge to Ground Permits[a]
Land Use	WS Wells Over 100K GPD[a]
Major Drainage Basins	
Drainage Subbasins	**Dependent upon Orthophotos**
Hydrography	
Aquifers	1:5000 Streams
Public Water Supplies[a]	1:5000 Wetlands
DEP Approved Zone IIs[a]	1:5000 Digital Terrain Models
EPA Designated Sole Source Aquifers	1:5000 Landuse
Surficial Geology	1:5000 Roads
Protected Open Space	
Areas of Critical Environmental Concern	**Logical Next BRP Layers**
(ACECs)	
Census TIGER Data	Wetlands Permits
Hypsography	Chapter 91 Permits
1:250,000 Contours	Historic Shorelines
Permitted Landfills and TSDs[a]	WS, WPC Treatment Plant Locations[a]
	Sampling Locations
MassGIS Datalayer Development - Layers Requested by DEP Staff	NPDES Locations[a]
	UST Datalayer
	DEP Outside BRP
1:25,000 Streams	
1:25,000 Landuse	Waste Site Locations[a]
Soils	TURA Locations[a]
Cultural Resources	RCRA Sites[a]
Pesticide Application Areas	
FEMA Floodplains	**Applications**
Continuous Streams w/Flow Direction	
Coded Stream Segments	Water Quality Testing System (WQTS)[a]
	FMF/GIS Integration project[a]
	Compliance/Enforcement Application[a]
	MSCA Automated Search Function[a]

[a]FMF/GIS Linked Development.

A Statewide Approach to Watershed Management: North Carolina's Basinwide Water Quality Management Program

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The North Carolina Division of Environmental Management (DEM) has initiated a new statewide water quality management approach called *basinwide management*. Basinwide management is not a new regulatory program. Rather, it is a watershed-based management approach that features basinwide permitting, integrating of existing point and nonpoint source control programs, and preparation of a basinwide management plan report.

DEM is applying this approach to each of the 17 major river basins in the state as a means of better identifying water quality problems; developing appropriate management strategies; maintaining and protecting water quality and aquatic habitat; and ensuring equitable distribution of waste assimilative capacity for dischargers. Other important benefits of the basinwide approach include improved efficiency, increased cost-effectiveness, better consistency and equity, and improved public awareness and involvement in management of the state's surface waters.

A basinwide management plan document is prepared for each basin in order to communicate to policy makers, the regulated community, and the general public the state's rationale, approaches, and long-term strategies for each basin. The plans are circulated for public review and are presented at public meetings in each river basin. The management plan for a given basin is completed and approved preceding the scheduled date for basinwide permit renewals in that basin. The plans are then to be evaluated, based on follow-up water quality monitoring, and updated at 5-year intervals thereafter.

Basinwide Goals: Balancing Water Quality Protection and Economic Growth

The primary goals of basinwide management are (1) to identify and restore full use to impaired waters; (2) to identify and protect highly valued resource waters; and (3) to manage problem pollutants within each basin through development of consistent and effective long-range water quality management strategies that both protect the quality and intended uses of North Carolina's surface waters and allow for reasonable economic planning and growth.

How Did Basinwide Management Get Started—And Why Now?

North Carolina, like many other states, has been faced for years with a number of critical water quality management issues brought on by an increase in the number and size of wastewater treatment plants, population growth, changes in land use, protection of endangered species, and the emergence of nonpoint source pollution as a significant cause of water

quality degradation. These and other factors, such as the need to accommodate economic expansion, to meet Clean Water Act reporting requirements (305(b), 303(d), and total maximum daily loads) and to improve the efficiency of the water quality program have been pushing North Carolina to consider a watershed-based management approach. However, it was not until recently that several prerequisites to adopting this approach could be met. These included availability of appropriate technology (GIS, far-field wasteload allocation models, centralized data management), an experienced multidisciplinary staff, and upper management support. Once staff could see the pieces begin to fall into place about 6 years ago, development of the basinwide approach began to progress.

The North Carolina basinwide program stemmed from a series of staff meetings and facilitated workshops from 1987 through 1989. Ideas generated by these meetings were summarized in a draft program plan that was taken to public hearing and reviewed by the U.S. Environmental Protection Agency (EPA). A basinwide permitting schedule was implemented in 1990, and a final detailed basinwide program document entitled *North Carolina's Basinwide Approach to Water Quality Management: Program Description* (Creager and Baker, 1991) was published in August 1991. This document presents the objectives and rationale for basinwide management; outlines the procedures, time schedule, and format for preparation of basinwide plans; and describes the staff responsibilities for carrying out basinwide management. A basinwide program coordinator position was established in 1992. The first basinwide plan (Neuse River) was completed in February 1993 and issuance of NPDES permits will begin in April of 1993. Development of the basinwide management program was conceived and carried out by the Water Quality Section of the Division of Environmental Management. It was not the result of nor has it required any legislative action.

Structure and Basinwide Responsibilities Within the NCDEM Water Quality Section

The Water Quality Section is the lead state agency for the regulation and protection of the state's surface waters. It is one of five sections located within the Division of Environmental Management (DEM), an agency of the North Carolina Department of Environment, Health, and Natural Resources. The other sections in DEM are Ground Water, Air Quality, Construction Grants, and the Laboratory. The primary responsibilities of the Water Quality Section are to maintain or restore an aquatic environment of sufficient quality to protect the existing and best intended uses of North Carolina's surface waters and to ensure compliance with state and federal water quality standards. Policy guidance is provided by the Environmental Management Commission. The Water Quality Section is composed of over 200 staff members in the central and seven regional offices (Figure 1).

The major areas of responsibility are divided among four branches: water quality monitoring (Environmental Sciences Branch), permitting and enforcement (Operations Branch), water quality planning (Planning Branch), and wasteload allocation/TMDL modeling (Technical Support Branch). All four branches report to the Water Quality Section Chief, and the activities of all four branches are integrated into the basinwide management effort. Basinwide management is coordinated by the Program Coordinator located in the Planning Branch.

Water Quality Program Benefits of the Basinwide Approach

Three important program benefits of the basinwide approach include (1) *improved efficiency,* (2) *increased effectiveness,* and (3) *better consistency and equity.* First, by reducing the area of the state covered each year, monitoring, modeling, and permitting efforts can be focused; as a result, *efficiency* is increased as more can be achieved for a given level of funding and resource allocation. Second, the basinwide approach is in consonance with basic ecological principles of watershed management, leading to more *effective* water quality assessment and management. Linkages between aquatic and terrestrial systems are addressed (e.g., contributions from nonpoint sources), and all inputs to aquatic systems and potential interactive effects are considered. Third, the basinwide

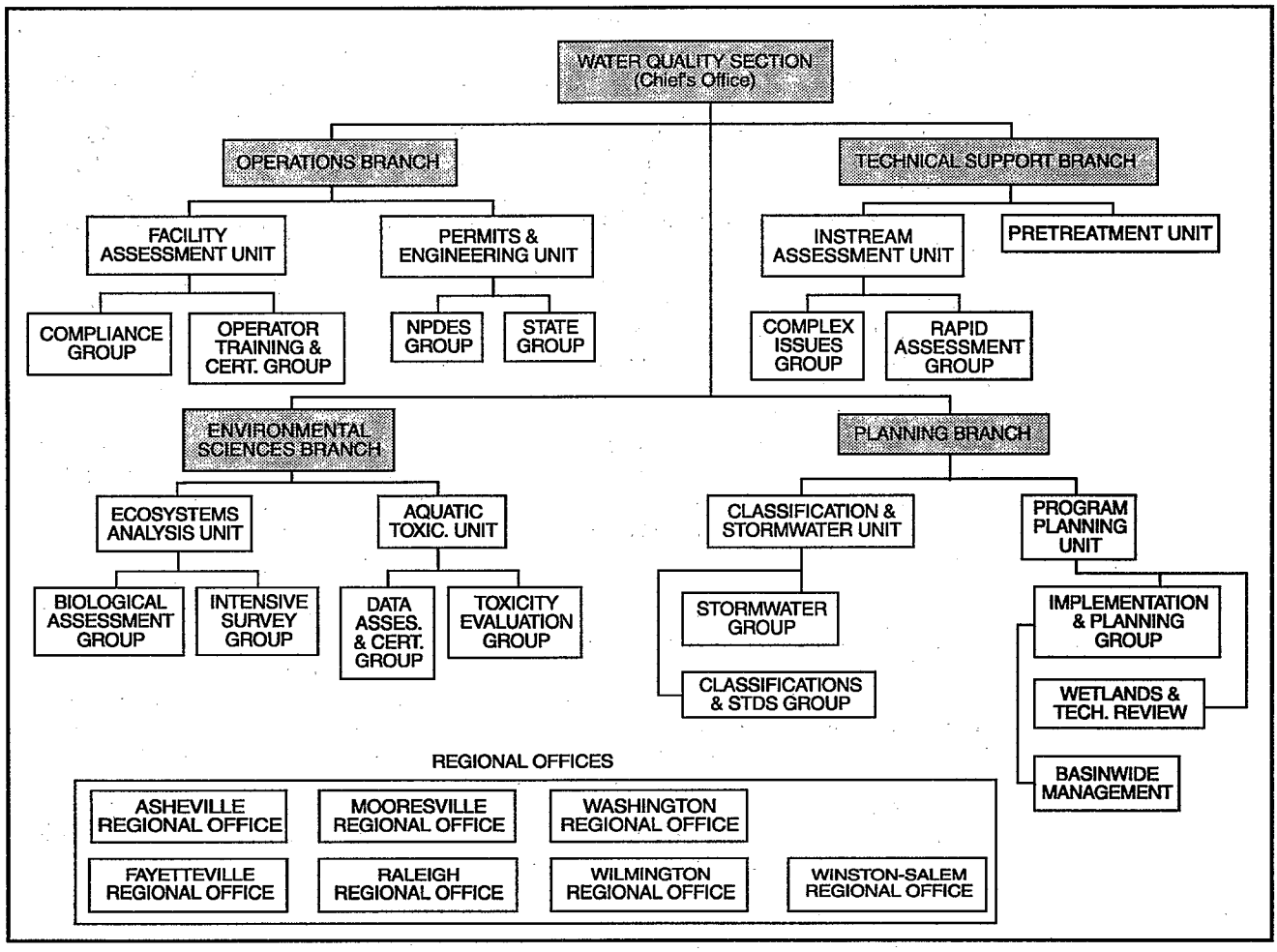


Figure 1. Organizational structure of the NCDEM Water Quality Section.

plans will provide a focus for management decisions. By clearly defining the program's long-term goals and approaches, these plans will encourage more *consistent* decision making. Consistency, together with greater attention to long-range planning, in turn, will promote a more *equitable* distribution of stream waste assimilative capacity, explicitly addressing the trade-offs among pollutant sources (point and nonpoint) and allowances for future growth.

Features of Basinwide Management

- *Basinwide NPDES permitting.* A basinwide NPDES permitting schedule was formalized in January 1990. All discharge permits for each basin are now scheduled to expire and be renewed in the same year beginning with the Neuse River in 1993. They are then to be reviewed and reissued at 5-year intervals thereafter. Prior to that time, permits were reissued randomly across the state as they came up for renewal.
- *Five-Year planning cycle.* The NPDES permit renewal schedule drives the schedule for water quality monitoring, wasteload modeling, total maximum daily load development, and basin plan development. Being able to schedule major work activities years in advance allows more efficient and effective use of staff resources. In addition, each ensuing cycle provides an opportunity for evaluation of the success of previous strategies toward meeting established goals.
- *Focusing all water quality programs and activities on one river basin at a*

time across the state. NCDEM is applying the basinwide approach to each of the 17 major river basins in the state as a means of better identifying water quality problems; developing appropriate management strategies; maintaining and protecting water quality and aquatic habitat; and ensuring equitable distribution of waste assimilative capacity for dischargers.

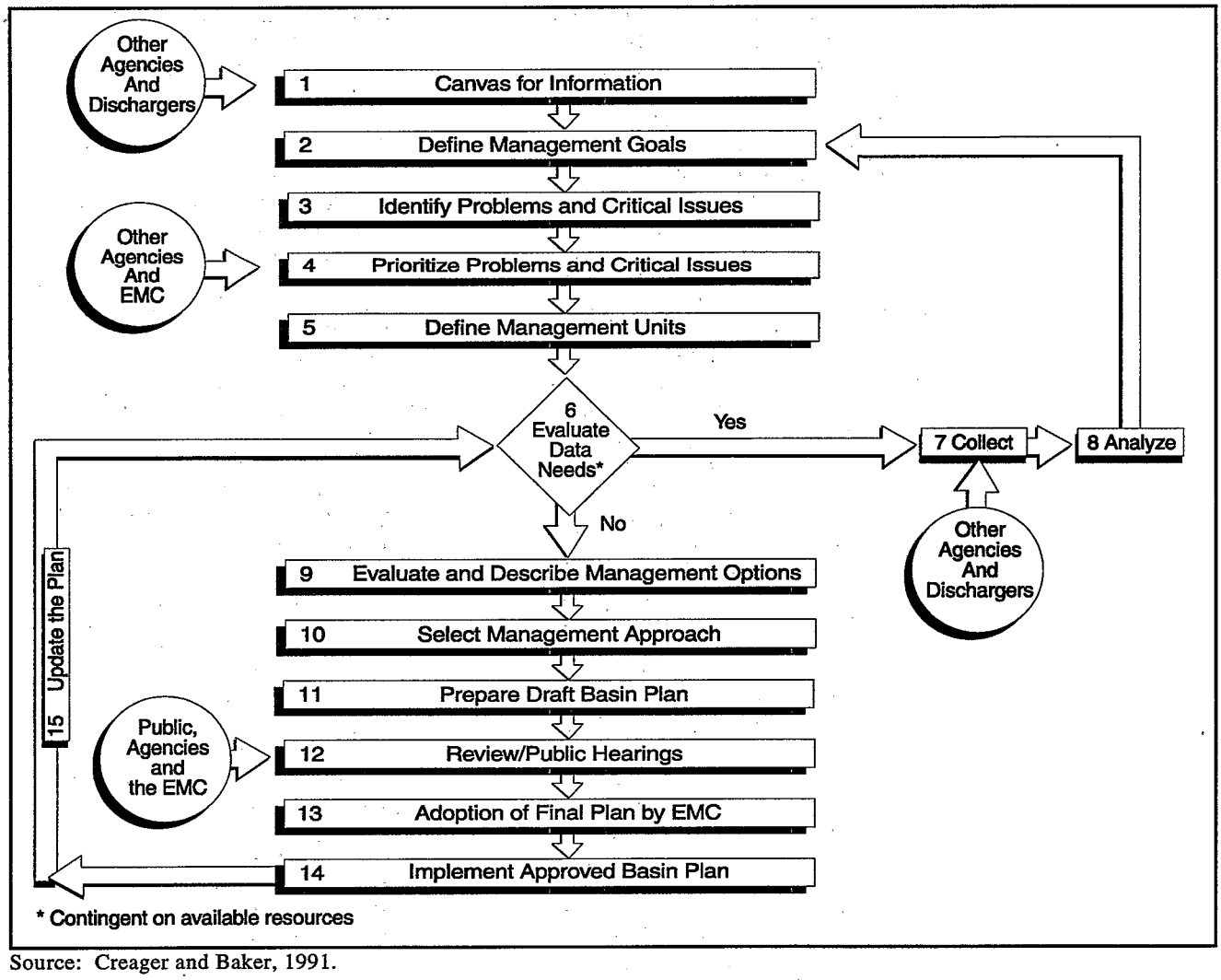
- *Sound ecological planning.* Basinwide management entails evaluating an entire river system at a time and not just stream fragments and individual facilities. This approach allows for better understanding and correction of water quality problems where the problems are far removed from the source or where downstream impacts result from cumulative effects of point and nonpoint sources. Understanding and maintaining the health and productivity of a river's ecology is a requirement of a successful basinwide management program.
- *Integrating point and nonpoint source pollution control programs.* Basinwide management will facilitate the integration of point and nonpoint source pollution assessment and controls through *total maximum daily loads* (TMDLs). The TMDL concept, which is introduced in the Clean Water Act, is based on the ideal of determining the total waste (pollutant) loading, from point and nonpoint sources, that a waterbody can assimilate while still maintaining its water quality classification and standards. While actually determining the allowable total maximum daily load for a river or waterbody is extremely difficult, due, in part, to difficulties in accurately quantifying nonpoint source loading, the TMDL approach, with reservations, is still useful for developing point source control strategies and targeting areas for nonpoint source management. Once a TMDL has been established for a basin and/or its components such as lakes, streams, or estuaries, point and nonpoint source control strategies can be developed to prevent overloading of the receiving waters; to allow for a reasonable margin of safety; and to optimize assimilative capacity.
- *Preparing basinwide management plans.* A basinwide management plan is an educational and information document, written in lay language, that is prepared for each basin in order to communicate to policy makers, the regulated community, and the general public the state's rationale, approaches, and long-term strategies for each basin. The plans are circulated for public review and are presented at public meetings in each river basin. The management plan for a given basin is completed and approved preceding the scheduled date for basinwide permit renewals in that basin. The plan does not include actual waste limits for individual dischargers. Wasteload allocations are developed for each individual facility in consonance with the TMDL strategy outlined in the basin plan.
- *Flexibility.* An underlying philosophy of the basinwide approach is to create a management framework that can evolve over time to accommodate new EPA requirements or take advantage of advancements in point and nonpoint source controls. North Carolina sees basinwide plans improving from basin to basin and from cycle to cycle.
- *Long-range planning.* A major intent of the basinwide approach is to utilize the TMDL approach and predictive modeling to show the consequences of growth and development activities on water quality and to develop long-range protection strategies. With sufficient lead time and involvement in the planning process, local governments, industry, and others can plan their activities to work in consonance with these strategies.
- *Promoting increased public involvement in and understanding of the state's water quality program.* As indicated above, public involvement and cooperation in the basinwide planning process is extremely important. NCDEM promotes involvement in the early stages of the basin planning effort in each basin through meeting with local leaders and interest groups. Forma-

tion of basin associations is encouraged, often through councils of governments. In addition to participating in the planning process, public support for water quality protection programs, particularly nonpoint source programs, is needed if they are to be successful. Such support is needed for passage of meaningful laws and regulations and for approval of funding to allow legislation and water quality protection programs to be effectively implemented. Basinwide management attempts to accomplish this through documenting and explaining the causes and sources of water quality problems in the basin plans.

Basinwide Plan Preparation, Review, and Public Involvement

Preparation of an individual basinwide management plan is a 5-year process that is broken down into 15 steps in Figure 2 and is broadly described below.

Years 1 to 3—Water Quality Data Collection/Identification of Goals and Issues (steps 1 through 7). Year 1 entails identifying sampling needs and canvassing for information. It also entails coordinating with other agencies, the academic community, and local interest groups to begin establishing goals and objectives and identifying and prioritizing problems and issues. Biomonitoring, fish community and



Source: Creager and Baker, 1991.

Figure 2. Major steps and information transfers involved in the development of a basinwide management plan.

tissue analyses, special studies, and other water quality sampling activities are conducted in years 2 and 3 by DEM's Environmental Sciences Branch (ESB) to provide information for assessing water quality status and trends throughout the basin and to provide data for computer modeling.

Years 3 to 4—Data Assessment and Model Preparation (steps 7 to 9). Modeling priorities are identified early in this phase and are refined through assessment of water quality data from ESB. Data from special studies are then used by DEM's Technical Support Branch (TSB) to prepare models for estimating potential impacts of waste loading from point and nonpoint sources using the TMDL approach. Preliminary water quality control strategies are developed as the modeling results are assessed. Further coordination occurs with local governments, the regulated community and citizens' groups during this period.

Year 4—Preparation of Draft Basinwide Plan (Steps 9, 10 and 11). The draft plan, which is prepared by DEM's Planning Branch, is due for completion by the end of year 4. It is based on support documents prepared by ESB (water quality data) and TSB (modeling data and recommended pollution control strategies). Preliminary findings are presented at informal meetings through the year with local governments and other interested groups, and comments are incorporated into the draft.

Year 5—Public Review and Approval of Plan (Steps 12, 13 and 14). During the beginning of year 5, the draft plan, after approval of the Environmental Management Commission (EMC), is circulated for review, and public meetings are held. Revisions are made to the document, based on public comments, and the final document is submitted to the EMC for approval midway through year 5. Basinwide permitting begins at the end of the year 5.

Each basinwide management plan includes seven chapters: (1) An introduction describing the purpose and format of the plan, Water Quality Section responsibilities and enabling legislation; (2) a general basin description including land use, population trends, physiographic regions, and classifications and standards; (3) an overview of existing pollutant sources and loads within a basin and a more generic description of causes and sources of point and nonpoint source pollution for the lay person; (4) an assessment of the status of water quality and biological communities in the basin including use-support rating and Clean Water Act section 305(b) information; (5) a description of the TMDL approach and the state's NPDES and nonpoint source control programs; (6) priority water quality issues and recommended control strategies, including TMDLs; and (7) implementation, enforcement, and monitoring plans.

Basinwide Plan Schedule

Table 1 presents the overall basin schedule for all 17 major river basins in the state. The dates represent the time at which permit reissuance begins. The management plan for a given basin is due for completion prior to the scheduled date for permit renewals in order to be available for the permit renewal decision-making process. The final basin plan is due for completion 4 to 6 months prior to that date. Draft plans are due for completion a year in advance for public review.

The number of plans to be developed each year varies from one to six and is based on the total number of permits to be issued each year. For example, the Cape Fear basin, the state's largest, has about as many dischargers as all six of the small basins in 1997. This has been done in order to balance the permit

Table 1. Basinwide permitting schedule for North Carolina's 17 major river basins

Month/Year	Basin	Month/Year	Basin
April 1993	Neuse	January 1997	Roanoke
		June 1997	White Oak
November 1994	Lumber	August 1997	Savannah
		September 1997	Watauga
January 1995	Tar Pamlico	October 1997	Little Tennessee
April 1995	Catawba	December 1997	Hiwassee
August 1995	French Broad		
November 1995	New	January 1998	Chowan
		January 1998	Pasquotank
January 1996	Cape Fear	April 1998	Neuse (2nd cycle)
		July 1998	Yadkin
		November 1998	Broad

processing workload from year to year. In years where more than one basin is scheduled to be evaluated, an effort has been made to group at least some of the basins geographically in order to minimize travel time and cost for field studies and public meetings.

The earliest basin plans, particularly the Neuse, may not achieve all of the long-term objectives for basinwide management outlined above. However, subsequent updates of the plans, every 5 years, will incorporate additional data and new assessment tools (e.g., basinwide water quality modeling) and management strategies (e.g., for reducing nonpoint source contributions) as they become available.

Conclusions

North Carolina is still faced with basically the same water quality challenges that were outlined earlier in this document. The major difference now, however, is that the state, through implementation of basinwide management, now has an established plan and the tools for taking significant steps toward addressing these issues. The basinwide approach reduces the seemingly endless set of water quality issues into more manageable units defined both geographically (by river basin) and temporally (by 5-year permit review/renewal and basin plan update intervals). The NPDES permit rescheduling provides structure to the state's water quality program, enabling program activities to be conducted in a more effective, efficient, and consistent manner. The geographic breakdown allows for closer evaluation of water quality status, identification of impaired waters, and development of appropriate management strategies within each basin. The 5-year update intervals offer a convenient and realistic time frame for measuring the progress of pollution reduction strategies. And a mechanism has been developed to encourage broader public understanding and participation in water quality protection and the development of long-term management strategies.

References

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Minnesota's Comprehensive Watershed Management Initiative

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Background

In 1991, resource managers across the State of Minnesota were queried as to their views on aquatic resource management in the state. In this study, managers were asked a series of questions about opportunities, programs that were working, those that had outlived their usefulness, management problems, and obstacles to effective management.

While this investigation provided much useful information, it was especially noteworthy that the following themes appeared with regularity in the interviews:

- Symptoms of water resource management problems are treated, rather than the sources of those problems.
- Land and water resource management responsibilities are fragmented, making it impossible to manage resources in a comprehensive and holistic manner.
- It is time to redirect dollars and staff to managing land and water resources from a watershed rather than a program perspective.

While these findings are noteworthy, they are not surprising. They are obvious to natural resource managers who see the effects of cumulative impacts on resources. They do so without the benefit of a holistic framework or an array of comprehensive management tools with which to address the problem of cumulative impact. Other water resource management efforts across the country have reached parallel conclusions. The major recommendation coming out of this study was to develop and put into place several prototype comprehensive watershed management projects spread geographically around Minnesota. That recommendation also identified the need for each project to be staffed by a coordinator who would be instrumental in all phases of the project from start-up through implementation and monitoring and evaluation.

Several criteria were developed to solicit project proposals. The most important criterion was a strong nucleus of local support and interest. A summary of the criteria is as follows:

- Strong nucleus of local support and interest.
- Presence of a variety of natural resource elements.
- Strong potential for intergovernmental coordination and effective partnerships.
- Results of prototype projects forthcoming within a reasonable time frame.
- Existence of potential funding sources.
- Sufficient data to initiate the project.
- Strong agency and local leadership available to guide project.

Out of nearly 20 project proposals submitted, 8 were chosen (see attached map). These eight best met the stated criteria and were representative of the wide range of ecosystems that occur in Minnesota. As of this date (March 1993), four projects are online, with the other four awaiting funding for project coordinators.

Project Themes

Four themes are intertwined throughout each of these pilot projects. The first theme is the comprehensive nature of the projects. Each project addresses resource

issues from an ecosystem perspective. One of the keys to this approach is understanding the capabilities and limitations of the natural systems in a given watershed. The approach is flexible in that it can be used in settings that range from nearly pristine—where the goal is to protect the status quo—to highly perturbed watersheds, where the objective is aquatic ecosystem rehabilitation.

Genuine and extensive citizen participation is the second theme. The success of comprehensive watershed management will depend on extensive citizen participation and ownership of the process. The process has to be convenient and friendly for the public to use. Existing paradigms of inaccessible government and the widely held feeling that individuals cannot make a difference need to be discredited. These efforts will only be successful if there is strong local commitment and interest.

Effective partnerships are the third theme of this effort. All state and federal resource agencies with land and water resource management responsibilities, local units of government, private organizations, and citizens will be invited, encouraged, goaded, or shamed into participating. Inherent in this mix of partners will be skills that can be applied to technical and organizational matters; programs with various diagnostic, implementation, monitoring, and evaluation components; and general support and funding assistance. All partners agree to manage for common goals and objectives developed in the planning process. This will often require development of formal multijurisdictional arrangements. Improved efficiency and economy of government operations will result as these cooperative efforts progress.

The last theme has to do with the long-term orientation of comprehensive watershed management. A true long-term outlook is difficult to achieve as most people are accustomed to thinking about a short-term perspective. It is more difficult to achieve by also having to think in the large spatial perspectives of a watershed. Initially, some boundaries that restrict thinking will have to be knocked down. These boundaries are being overcome in project watersheds through a series of focused educational activities. These activities describe and inform project partners about the geomorphological history of the watershed; human-induced change; and various ecosystem metrics (e.g., land use, demographics, water quality, plant and animal communities). Most importantly, these efforts inform the public about the future of the watershed if we continue to manage as we have in the past.

Project Approach

The approach being used to implement pilot watershed projects is simple and straightforward with variations peculiar to each project watershed. The general outline is as follows.

The first step is to provide information to project partners about the existing condition of the natural resource systems in the watershed, how existing conditions compare to historical conditions, and the capabilities and limitations of natural systems in the watershed. The second step is to describe what the watershed should be like in the future using a 50-year time frame. This involves gathering extensive public and agency input about the desired future condition of the watershed. The process of defining the desired future condition allows for the development of a collective long-term vision of the preferred environmental, societal, and economic conditions in the watershed.

The third step involves development of a comprehensive watershed management plan—a plan that is developed and agreed upon by all project partners. The statements about the desired future condition of the watershed, developed previously, constitute the basis for the plan's goals, objectives, strategies, and actions. The intent is to develop and agree to implementation of a comprehensive watershed management plan that makes the desired future condition a reality.

These actions are logically followed by the implementation of the comprehensive watershed management plan replete with monitoring and evaluation components designed to assess the effectiveness of project efforts over the long term.

Benefits

The benefits of engaging in comprehensive watershed management as it is described in this paper are the following:

- Needs and action are prioritized.
- Dollars and personnel are used efficiently.

- There is extensive development of partnerships among land and water resource management agencies, local units of government, landowners, and special interest groups.
- Everyone participates and agrees to actions developed in a comprehensive watershed management plan.
- Long-term solutions to issues and problems are developed.
- Natural resource systems are protected or improved.

Outcomes

What does all of this lead to? From the project standpoint, it leads to a comprehensive watershed management plan that is citizen owned, an organization to implement the plan, long-term monitoring and evaluation, and multijurisdictional agreements on implementation, evaluation and future needs. It also leaves in place a process that is conducive to new ideas and can accommodate changes in ecosystem understanding and societal values.

From an agency standpoint, the intent is to use this initiative as a first step in changing the way we do business as natural resource management agencies. In Minnesota, we are seeing an evolution toward more intergovernmental cooperation, co-location of offices, teams working on watershed units, reorganization of natural resource management agencies along watershed or other natural boundaries, and an increased and genuine emphasis on involving the public early and often.

A Problem-Solving Partnership

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The need to pursue soil and water conservation measures on a "water shed" or "problemshed" basis is certainly not a new idea. When the first soil conservation districts were organized in Nebraska in the late 1930s, they were organized along hydrologic boundaries. Even then, the necessity for landowners to work together to solve common problems was recognized.

Unfortunately, the watershed boundary idea was short-lived. As the soil conservation district movement spread rapidly, an easy and simple procedure called for organization along county lines. The entire state was blanketed with soil conservation districts between 1938 and 1949. The county boundary system worked well for that decade of the '40s and on into the early '50s because most of the soil and water conservation efforts were directed at individual farms. Then things started to change.

Congress enacted a pilot watershed program and followed with the National Watershed Protection and Flood Prevention Act (P.L. 566) in 1954. As Nebraska's soil and water conservation district leaders considered sponsorship for small watershed projects, they soon recognized the necessity of a "watershed team" approach. The district supervisors also learned quickly that a source of local funding would be necessary to acquire easements and rights of way. Furthermore, they were told that local sponsors had to assume operation and maintenance of the watershed structures once they were built, and at times they also might need the right of eminent domain.

The solution to that problem was fairly simple. The course of the past was followed—when a new problem came up, you went to the Nebraska Legislature to organize a special purpose district to help solve the problem. Thus, in 1957, the Watershed Conservancy District Act was passed. The districts were to be established to coincide with boundaries of proposed watershed projects. The Legislature also granted the new Watershed Conservancy Districts the right of eminent domain as well as a small taxing authority. Once again, after the law passed in 1958, until about 1968, districts were formed rapidly to support the rising demand for the small watershed program in the state. Some districts were small as the watersheds were small. This fact presented a problem right away.

It wasn't long until it became apparent that once again taking the easy way out wasn't the right way. While the Watershed Conservancy Districts were doing the best they could to carry out their responsibilities, the necessity to move the watershed program ahead at a more rapid pace was apparent.

In 1964 conservation leaders began discussing the future for conservation districts in the state. As they looked around, some called the situation "districtitis," as there were many overlapping districts with similar authorities. As is often the case, though, this group found that they were not the first to study the problem in the state. In 1939 the Legislative Council in Nebraska had conducted a study on the "Multiplicity of Governmental Units." The conclusion of that study revealed that the state had "too many small governmental units with single functions to ever do an efficient job, or in some cases to ever get the job done."

No one took heed of the 1939 study when at that time there were 172 special-purpose districts dealing with some type of a natural resource problem. By the time things were moving in 1964, the Nebraska Legislature had permitted the organization of over 500 special-purpose districts to deal with aspects of soil and water resources.

Something had to be done, and a great effort took place between 1964 and 1972, the year when Nebraska's 24 Natural Resources Districts became operational. One hundred and fifty-four existing districts were consolidated into 24. The new districts were organized on hydrologic boundaries and had broad powers, including taxation authority to ensure projects could be carried to completion. The law also limited the formation of new special-purpose districts in the future to avoid continuation of overlapping functions.

The task was not easy. Any reorganization involving many interests can be overwhelming at times. But after a long hard battle, the Nebraska Unicameral Legislature passed the reorganization legislation on September 18, 1969. The vote was 29 for, 9 against, and 11 not voting. The districts were to become operational in 1972. Even after that, there were many problems to confront before the new districts became operational.

Steve Gaul (Gaul, 1993) adds some historical perspective as he gives due praise to Warren Fairchild, who was Executive Secretary of the Soil and Water Conservation Commission at the time and the leading proponent of the restructuring. Two decades after the districts came into being in Nebraska, Fairchild was asked to return to Nebraska and accept an award that would praise his political courage for efforts in creating the Natural Resources Districts. Gaul relates, "In 1968 it probably didn't feel like courage. It may have felt more like the insanity to brave hell on a warm day."

With the Natural Resources District (NRD) organization, Nebraskans have been solving resource problems on a watershed basis for 20 years. While flood control is still an important aspect, there is now a greater emphasis on many environmental issues. The districts have many responsibilities, including water quality protection. The NRD organization lends itself well to addressing nonpoint pollution problems that also must be solved on a watershed basis.

Take, for example, the Lower Platte North Natural Resources District in eastern Nebraska, which is doing extensive work in updating a proposal to build flood control structures in the Wahoo Creek Watershed. The Soil Conservation Service has developed a flood control project through the P.L. 566 program in the 249-square-mile project area. The proposed project has an excellent cost-benefit ratio, but the NRD wants to do more before deciding on a future plan for the watershed. They recognize that, through a careful analysis, even greater benefits could be recognized. The district is now working with the U.S. Geological Survey (USGS) to gather water quality data. They have made a careful evaluation of the flood plain study in the area and are now directing great deal of attention toward nonpoint source pollution control in the watershed area. At the request of the district, a consulting firm has developed an Agricultural Nonpoint Source Model to provide a better base upon which to make proper, prudent land treatment decisions. Here is a district taking an extreme interest in water quality benefits as well as flood control benefits, and if successful their work will mesh with the work of the U.S. Environmental Protection Agency, the USDA Soil Conservation Service, USGS, and others. An updated soil survey is also underway to make sure a "holistic" view of the entire watershed can be made. Through the efforts of many, benefits can far exceed the flood control and recreation benefits from the watershed project.

Over the past several years, it has become more obvious that many states are having a great deal of difficulty working with water- and soil-related issues at the local government level. In fact, it probably does not come as a surprise to learn that nearly all states are having difficulty working things out at their own level.

Much has been said about "water decision gridlock." Since May 1991, the Western Governors' Association and the Western States Water Council have held a series of workshops at Park City, Utah. The workshops were called for the purpose of exploring innovative solutions to resolve complex water management problems. The Park City Principles, the resultant work product, outlines the concept that a "problemshed" approach must be incorporated into important natural resources decisions. Often, ideas for solutions to problems can "bubble up" and these localized ideas may prove to be more reasonable and cost-effective. It is easy to recognize that problem solving costs are high when standardized Washington, DC, solutions are put into effect.

States have also found themselves in a constant reactive situation. With federal "command and control" legislation, states spend a great deal of time in an "offensive posture." States must find themselves in the

role of providing solutions to problems long before a national edict is presented. In order to be on the positive side, representatives of state government also feel strongly that states should assume a strong "pivotal" role in handling natural resources issues. However, if you are to pivot, to whom do you pivot if a strong local natural resources agency does not exist?

At the 1992 National Water Policy Roundtable, sponsored by the Interstate Council on Water Policy, participants responded to the question, "What is not working and needs improvement?" Two of the issues listed were:

- In water planning and management, the fundamental unit of analysis should be the watershed or problemshed.
- We must advance a more systematic and clearly articulated conceptual base for decision making—one that matches the puzzles encountered at the watershed or problemshed level.

These are just a few of the ideas that came out of the Water Policy Roundtable, but the ideas leave little doubt that it is very important to address needs in an area that encompasses the problem and a wide variety of affected interests must participate in the decision-making process.

In summary, in any self-assessment that states may do on their own accord, "building capacity" to handle natural resources issues surely will be judged as a high priority. In order to build such capacity, local government must also be empowered to handle a wide variety of natural resource problems. Approaching the problem on a watershed basis makes good common sense.

Fifteen Years of Progress: Wisconsin's Nonpoint Source Water Pollution Abatement Program

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Fifteen years ago, the Wisconsin legislature stepped ahead and created one of the first state nonpoint source programs. Most legislators would admit that they knew very little about water quality problems caused by pollutants in runoff. However, they knew that something had to be done to abate the water quality problems that weren't caused by point sources.

Wisconsin prides itself on its pristine lakes, sparkling streams, and drinkable ground water. Water quality is an important part of Wisconsin's quality of life and its economy. However, reality differs from the image the tourism promotions convey. In its "Ill Waters" series on nonpoint sources of water pollution, the *Milwaukee Journal* stated,

> Once-pristine lakes now choked with weeds and algae. Winding rivers clogged with mud. Rippling trout streams dammed into oblivion. Drinking wells contaminated with nitrates. (*Milwaukee Journal*, November 10, 1989)

The purpose of this paper is to review the 15 years of progress of the Wisconsin Nonpoint Source Water Pollution Abatement Program, to relay its success, and to discuss its inadequacies.

Water Quality Problems

In Wisconsin, the Department of Natural Resources estimates urban and rural nonpoint sources threaten or degrade about 40 percent of the 30,000 miles of streams, over 75 percent of the 15,000 inland lakes, and much of the ground water. While the extent of the water quality problems is great, they do not describe the impaired and lost uses. In 1968, some outdoor publications boasted of southwest Wisconsin's smallmouth bass fishery. Today, the smallmouth bass fishery is nearly gone. Fish kills caused by manure in runoff from animal lots occur almost every year.

Trout streams in the coulee region of western Wisconsin have sediment covering spawning beds, and vegetative cover on streambanks is less than adequate. Grazing cattle and eroding croplands are the major cause. Sediment carried by these streams has nearly filled many Mississippi River backwater areas.

Throughout Wisconsin, many deep lakes have severe algae problems. For example, Tainter Lake in the northwestern part of the state is pea green, and bacteria levels restrict swimming. Lake Mendota, a heavily used lake near Madison, no longer supports a cold water fishery due to the loss of dissolved oxygen in its bottom waters. Algae in Green Bay, a part of Lake Michigan, is so dense that it significantly decreases oxygen levels. It also causes turbidity levels high enough to prevent rooted aquatic vegetation from growing.

Because of extensive monitoring in recent years, the extent of ground-water contamination has become evident. On the average, about 14 percent of Wisconsin's private wells have nitrate levels exceeding the 10 mg/l enforcement standard. This does not include sandy areas, such as the central sands area, where nitrate levels of 30 mg/l are common.

Wisconsin's Approach

Wisconsin's approach to urban and rural nonpoint source control emphasizes management on a watershed approach. The Wisconsin Nonpoint Source Water Pollution Abatement Program's watershed projects are called "Priority Watershed Projects." There are three types. The large-scale projects range in size from 30 to nearly 300 square miles, averaging about 150 square miles. Small-scale projects dealing with an individual lake or stream range from three-fourths of a square mile to 12 square miles. Priority lake projects do not have a size limit, but deal with problems in a lake or chain of lakes. In 1978, the program started with five large-scale projects.

Key aspects of Wisconsin's program are as follows:

- *State-level administration and oversight.* The Department of Natural Resources, the state water quality agency, administers the nonpoint source program with involvement of the Department of Agriculture, Trade and Consumer Protection. The Department of Natural Resources develops and approves priority watershed plans, provides grants for cost sharing and local staff support, and monitors water quality. The Department of Agriculture, Trade and Consumer Protection participates in priority watershed planning, assists counties, and takes a lead role in agriculture best management practice development.
- *Local implementation and technical assistance.* Counties, through their land conservation departments; cities; villages; and lake districts participate in priority watershed planning, and are responsible for project implementation, especially technical assistance. Counties must approve priority watershed plans that guide implementation. The program fully supports local staffing.
- *Water quality-based projects.* Each priority watershed project is tailored to meet the specific problems in the watersheds, lakes, streams, and ground water.
- *Critical sites identified.* Using a variety of urban and rural nonpoint source models, critical sites are identified in each priority watershed.
- *Voluntary participation.* Landowners, operators, and municipalities of critical sites, as identified in approved priority watershed plans, may voluntarily participate in the program. To participate, the landowner, operator, or municipality must agree to install and maintain best management practices needed to control all critical sites.
- *Educational assistance.* Educational assistance is provided to each priority watershed project. Newsletters, demonstration sites, and local coordinating committees are a few of the methods used.
- *Cost-share assistance.* State funds are available to cost share the installation of best management practices. Generally the cost-share rate is 70 percent. In each project, landowners or operators have 3 years to sign cost-share agreements and 5 years to install the needed cost share agreements.
- *Focused water quality monitoring.* To most effectively use staff and financial resources, water quality monitoring is focused into a small number of sites where intensive monitoring is conducted.

Where Is Wisconsin Today?

Since 1978, Wisconsin's efforts have grown dramatically in many ways. As shown in Figure 1, the number of priority watershed projects has grown from the initial 5 to 60, encompassing about 7,500 square miles. The magnitude of the program is also illustrated through a number of factors, including:

- *Substantial state investment.* Presently, the program is projected to spend over $10 million in 1993 and increase to over $16 million in 1994 and again in 1995. Overall, Wisconsin has spent nearly $50 million to implement its efforts.
- *Significant local support.* In 1993, the program is fully supporting over 100 county and other local-level staff.
- *Ample education budget.* Wisconsin is supporting over $600,000 annually for education efforts, not including demonstration practices.

- *3,000 cost-share agreements.* Since 1978, about 3,000 cost share agreements have been signed to control critical nonpoint sources. This includes over 800 during the last 3 years. Also in the last 3 years, best management practices have been installed to control: nearly 500 critical animal waste sites; about 32,000 critical cropland acres; and about 177,000 feet of critical streambanks.

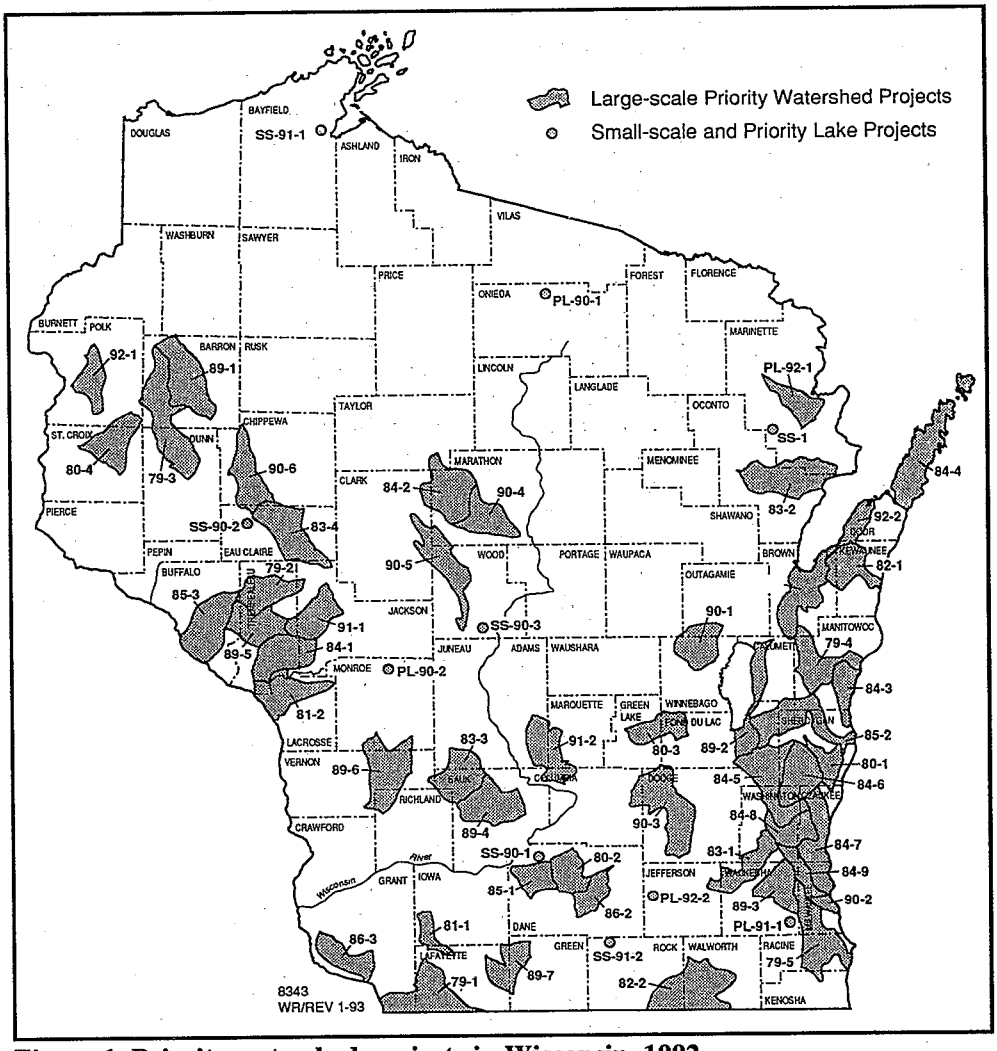

Figure 1. Priority watershed projects in Wisconsin, 1992.

Successes

While Wisconsin's efforts over the last 15 years have been substantial, true success is not measured by the dollars spent or number of cost share agreements signed. Wisconsin's legislature and public want to see success in terms of improved water quality. Water quality improvements have been documented, but improvements have been limited to small trout streams with degraded habitat caused by unmanaged cattle access.

Vance Creek in the Hay River Priority Watershed Project in northwestern Wisconsin is an example of documented water quality improvements. Department of Natural Resources staff conducted fish population surveys on this small trout stream before and after fencing cattle out of the stream and controlling runoff from an animal lot. As shown in Table 1, the number of trout doubled and the population shifted from the more tolerant brown trout to the less tolerant brook trout. Similar results have been documented on other small streams across Wisconsin.

Water quality improvements have not been documented in larger streams and lakes for a number of reasons, particularly:

- Insufficient levels of participation by owners or operators of critical sites and
- Response time of the body of water.

In small streams similar to Vance Creek, water quality improvements have not been seen where owners or operators of critical sites decline to participate. Generally, degraded or impaired streams need high levels of pollutant reduction to accomplish a measurable water quality improvement. Overall, the level of participation for critical sites ranges from about 25 percent to about 75 percent. The average is just about 50 percent.

The reasons for declining to participate are many, for example potential participants may:

- See no economic advantage.
- Be against government programs.

Table 1. Brook and brown trout captured, Vance Creek, 1975, 1981, 1983, and 1990 (2,100 feet surveyed)

	Brook			Brown			All Trout		
Year	<4"	>=4"	Total	<4"	>=4"	Total	<4"	>=4"	Total
1975	10	33	43	34	73	107	44	106	150
1981	31	10	41	51	117	168	82	127	209
Best Management Practices Installed									
1983	112	104	216	73	165	238	185	269	454
1990	145	262	407	9	44	53	154	306	460

Source: *Hay River Priority Watershed Project: Final Report*, Wisconsin Department of Natural Resources, January 1991.

- Not see any reason to change.
- Plan to retire.
- Not be able to afford the participant's share.

The response time for a body of water varies with the type of problem and the type of body of water. For example, the response time for streams with dissolved oxygen depletion during runoff events should be very short. On the other hand, the response time for lakes may be the equivalent of two or three residence times.

The Near Future

Over the last 2 years, the Legislature, Governor, and citizens of Wisconsin have discussed and debated the future of the state's nonpoint source program. They expressed a need to see improvement in Wisconsin lakes, streams, and ground water at a much faster pace than the nonpoint source program has been pursuing. Last May, Governor Thompson signed legislation establishing a goal to start implementation of all needed priority watershed projects by the end of the year 2000. This acceleration requires doubling the number of new projects started each year from about 6 to 12 or 13.

The voluntary nature of the program has also been discussed at length. A committee of legislators and citizens concluded that Wisconsin's water quality goals cannot be achieved with a strictly voluntary nonpoint source program. Much of the debate is focusing on what form of mandatory compliance is needed, and less on whether it is needed. Recently, the Governor's budget included provisions to require participation in priority watershed projects.

Conclusion

Fifteen years of effort has shown substantial progress toward achieving water quality in Wisconsin's lakes, streams, and ground water. These efforts represent a major financial commitment from the Wisconsin legislature and significant work by state and local governments with assistance from federal agencies. Progress to date shows that water quality improvements can be achieved. Despite these commitments and efforts, it must be concluded that the "glass measuring accomplishments" is "half full." Many policy makers and citizens have concluded the Wisconsin is nearing the level of accomplishment that can be achieved through a strictly voluntary program. Proposals are being made to add a mandatory component to the priority watershed projects. Wisconsin is poised at the threshold, determining when—not whether—to step across.

Assessing the Impacts of USDA Water Quality Projects: Monitoring

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Nonpoint source pollution, particularly from agricultural land, is widely recognized as a significant cause of surface and ground water impairment throughout the United States. Land treatment programs fostering implementation of improved management practices are thought to be the most effective approach for the protection and improvement of water quality impaired by agricultural nonpoint source pollution. Evaluation of performance and documentation of lessons learned has been an essential part of land treatment-water quality programs from the Black Creek Project (Lake and Morrison, 1977) to the Model Implementation Program (Harbridge House, Inc., 1983) to the Rural Clean Water Program (Gale et al., 1993).

While we have learned a great deal about how to plan, organize, cooperate, and administer land treatment projects and programs, documented cases of water quality restoration have been rare. We must now try to go beyond land-based notions of success and show project effects directly on water quality. Measurement of success in watershed management must include assessment of project impacts on the impaired resource. If a program goal is to control lake eutrophication, for example, success should be measured by change in the condition of the lake, not simply by the number of practices implemented in the watershed. Water quality monitoring can play a key role in such evaluation.

The current programs of the U.S. Department of Agriculture (USDA) Water Quality Initiative—the Demonstration Projects (DPs) and the Hydrologic Unit Area projects (HUAs)—are now being evaluated. The overall evaluation considers project organization, producer adoption, and economic cost-effectiveness, as well as physical impacts—success at protecting or improving water quality. The Physical Impact Assessment, under the leadership of the USDA-Soil Conservation Service (SCS) is the subject of this paper. Specifically, the paper will analyze the role of water quality monitoring in the assessment of project effects.

Approach

Progress of a subset of 16 USDA DPs and HUAs toward goals relative to pre-project baseline conditions is being evaluated. The central concept of the Physical Impact Assessment (Assessment), which is described in detail elsewhere (Sutton et al., 1992) is that projects must document their impacts in one or more of three ways:

1. Documented changes in use and/or application of agrichemicals and animal wastes.
2. Simulated changes in sediment or agrichemical losses from the edge of field or bottom of root zone as predicted by models.
3. Monitored changes in surface or ground water quality.

Case-Study Group

Sixteen USDA-sponsored projects, the eight original (FY 1990) DPs and eight selected HUAs, were chosen as a case-study

group for the Assessment. These projects encompass a full range of geographic setting, agriculture type, and water quality problems characteristic of agricultural nonpoint source water pollution problems in the United States today. The projects selected are:

Demonstration Projects	Hydrologic Unit Areas
Sacramento River Rice Herbicide, CA	Sand Mtn/Lake Guntersville, AL
Lake Manatee, FL	Inland Bays, DE
Monocacy River Waterhsed, MD	Illinois River Sands, IL
Anoka Sand Plain, NE	Upper Tippecanoe River, IN
Mid-Nebraska, NE	Sycamore Creek, MI
Herrings Marsh Run, NC	East Sidney Lake, NY
Seco Creek, TX	Ontario, OR
East River, WI	Little Bear River, UT

Most of these projects fall into one of two groups based on the type of impaired waterbody, pollutants, and agriculture type.

The DPs in Maryland, North Carolina, and Wisconsin and the HUAs in Alabama, Indiana, Michigan, New York, and Utah are concerned primarily with surface waters impaired by sediment, nutrients, animal wastes, or bacteria generated by livestock production and/or nonirrigated cropland. Eutrophication, sedimentation, and oxygen demand have impaired rivers, lakes, and reservoirs for fisheries, drinking water, recreation, and aesthetics. Common agricultural management problems include lack of cropland and streambank erosion control, sediment delivery from cropland, excessive fertilizer application, lack of nutrient crediting for animal waste application, poor animal waste management, and inadequate dead animal disposal practices.

The Florida, Minnesota, and Nebraska DPs and the Delaware, Illinois, and Oregon HUAs focus primarily on contamination of ground water and associated surface waters with nitrates and pesticides leaching from irrigated cropland. High nitrate levels in ground water, excessive nitrogen loading to surface waters in base flow, and presence of pesticides in drinking water are typical water quality impairments. Common agricultural management problems include excessive nitrogen applications, cultivation on extremely sandy soils, poor irrigation-water management, and high pesticide applications. The Illinois HUA and the Nebraska DP work with threatened, rather than currently impaired, aquifers.

Two DPs do not fit into either of these groups. The Texas DP focuses on a closely interconnected surface water/ground water system in which improper animal waste and rangeland management threaten the drinking water aquifer for San Antonio. Nitrates and pesticides are the primary pollutants of concern. The California DP is concerned with reducing transmission of residues of herbicides from irrigated rice production to the Sacramento River system. Irrigation tailwater management is the primary agricultural management issue.

The overall goal of these USDA projects is voluntary and cost-effective protection or improvement of water quality from agricultural nonpoint source pollution. Within this broad charge, the Assessment projects have a variety of general goals:

- Demonstrate or bring about producer adoption of improved agricultural practices.
- Reduce nutrient and/or pesticide use
- Reduce nutrient and/or pesticide leaching and/or runoff to receiving water.
- Bring about improvement or protection of water quality in receiving waterbody.

Although the importance of setting specific and measurable water quality goals for agricultural water quality projects has been emphasized in the past (Harbridge House, 1983; Gale et al., 1992), most of the Assessment projects have not done so. Highly general goals do not provide a useful yardstick against which to measure progress.

To achieve their goals, the Assessment projects promote voluntary adoption of cost-effective agricultural management and land treatment practices to control or reduce nonpoint source pollutants within the project area. Because HUAs are located in areas with documented water quality impairments and emphasize management systems of proven effectiveness, they tend to promote widespread adoption of established practices. In contrast, DPs focus on testing innovative practices on a few sites and promoting wider adoption through demonstration and education.

Physical Impact Assessment

Land Treatment Implementation

The agricultural management and land treatment practices promoted in each project are generally derived from current SCS and Cooperative Extension Service recommendations and are tailored to the type of agriculture and nonpoint source problems in the project area. In the surface water projects, for example, practices implemented focus on erosion control, animal waste management, nutrient management, and riparian/streambank treatment to protect surface waters from sediment, nutrients, organic matter, and bacteria. Among the ground-water projects, the most common land treatment practices are integrated crop management, integrated pest management, and irrigation water management. Several projects are demonstrating highly specific, innovative practices such as fully enclosed seep irrigation in the Florida DP and irrigation tailwater holding and recirculating systems in the California DP.

All of the Assessment projects track practice adoption at some level, ranging from basic records on contracts signed to collection of detailed agrichemical management data. In 1992, the projects began to use new progress tracking software—Automated Data System for Water Quality (ADSWQ)—to facilitate documentation and reporting of practices installed to protect water quality (USDA-SCS and Texas A&M University, 1992).

Based on the information reported by the projects in FY 1992, there has been a substantial installation of practices between FY 1990 and 1992. A total of 118 different conservation practices have been installed. Nutrient management practices have been implemented in all 16 projects; pesticide management and erosion/sediment control practices have been applied in 11 of the 16 projects. The most widely-applied practices are shown in Table 1.

It should be noted that, while recording numbers or acres of practices implemented provides essential basic information, such information does not by itself constitute documentation of project impact on water quality.

Changes in Agrichemical Inputs

A first indication of project impact on water quality is documented change in nutrient and pesticide inputs. Reduced inputs should ultimately lead to reductions in agrichemical losses from the edge of field or the bottom of the root zone, thereby reducing pollutant loads to receiving waters.

The Assessment projects have reported estimated reductions in nitrogen, phosphorus, and pesticide applications relative to baseline conditions in their FY 1992 annual reports. However, firm documentation of actual improvements in agrichemical use has been complicated by a number of factors, including reliance on assumptions that producers have followed plans and that changes in pesticide use may be in timing and formulation, not simply reduction of quantity applied.

Data on actual changes in agrichemi-cal use have been well documented in several projects through collection of field data from producers on chemical or animal waste applications. While collecting such data requires a high level of effort from field staff, the effort is justified by the resulting documented evidence of management improvement. Complete field-by-field data may not always be necessary; a statistical sampling approach may provide sufficient data while controlling staff time costs.

Physical Process Modeling

Nearly every project in the case-study group is using one or more physical process simulation models, such as to

Table 1. Summary of most commonly installed practices, sixteen assessment projects

Practice	HUAs	DPs	Total
Waste Mgt. System (#)	96	2	98
Cons. Cropping Seq. (ac)	71,161	19,013	90,174
Cons. Tillage (ac)	69,829	6,512	76,341
Cover/Green Manure (ac)	23,312	26,761	50,073
Irrigation Pipeline (ft)	27,351	318,401	345,752
Irrigation Water Mgt. (ac)	16,094	58,388	74,482
Nutrient Mgt. (ac)	57,612	61,230	118,842
Waste Utilization (ac)	20,222	10,596	30,818
Soil Testing (ac)	5,458	9,554	15,012
Pest Mgt. (ac)	11,409	31,444	42,853

Source: FY 1992 project Annual Progress Reports.

estimate project impacts. Simulation models can be used in project planning to identify critical areas, predict levels of sensitivity in the hy-drologic system, and help evaluate EPIC (Erosion-Productivity Impact Calculator), GLEAMS (Groundwater Loading Effects of Agricultural Management Systems), or AGNPS (Agricultural Nonpoint Source Pollution Model), alternative treatment plans based on predicted changes in pollutant loads. In cases where no current water quality impairment exists or when very long lag times are likely to prevent documentation of actual water quality changes, simu-lation models may offer the only alternative to project impact assessment. Use of models to assess project impacts is discussed in detail elsewhere (Sutton, et al., 1993; Griggs and Sutton, 1993).

Water Quality Monitoring

Unlike simulation models which predict possible water quality response, water quality monitoring can, if conducted properly, document actual changes in receiving waters impacted by agricultural nonpoint source pollution. Monitoring can focus on physical conditions, chemical concentrations and loads, or the status of biological communities. Monitoring is considered the most convincing and defensible approach to evaluating water quality response to management changes (Gale et al., 1992; Coffey et al., 1993). Thus, monitoring results could be an important instrument of project impact assessment.

However, from the outset, policy guiding the DP and HUA projects has been that monitoring was the responsibility of other agencies. Monitoring was not included in the original designs of the Assessment projects. Most of the Assessment projects now include some form of water quality monitoring, generally added after the project began and not well-integrated into projects activities. Monitoring efforts underway include site-level monitoring of particular practices such as constructed wetlands; ambient monitoring of project area streams, lakes, or aquifer; extensive regional monitoring; and—in just a few cases—intensive studies specifically designed to evaluate the particular project. Most monitoring focuses on physical/chemical evaluation, but biomonitoring is an important activity in several projects. Mon-itoring in the Assessment projects typically suffers several limitations, including lack of financial and personnel resources, lack of specificity to the water quality impairment or land treatment program, and inadequate design.

The rest of this paper will focus on an analysis of the use of water quality monitoring in the Assessment and recommendations for monitoring in future evaluation programs.

Use of Water Quality Monitoring to Assess Project Impacts

Status of Monitoring and Evaluation

Nearly all of the projects that incorporate monitoring rely at least partially on state environmental or natural resource agency programs, which include:

- Ongoing, ambient monitoring programs which happen to include some stations or sites in the project area.
- Short-term intensive programs focused on some specific area or problem which overlaps the project area.
- Specialized monitoring programs specifically designed to serve the project.

The Michigan Department of Natural Resources, for example, is conducting a paired watershed study specifically to evaluate treatment impacts in the Sycamore Creek watershed (Suppnick, 1992).

Federal or regional agencies such as U.S. Geological Survey (USGS), USDA-Agricultural Research Service (ARS), and Tennessee Valley Authority are participating in some projects through ongoing, ambient programs or efforts specifically supporting the water quality project. The USGS, for example, is monitoring streamflow and water chemistry in the Texas DP). The USDA-ARS is operating stream monitoring stations in the North Carolina DP.

University researchers are conducting monitoring in some projects through the Cooperative Extension Service (CES) or through the Agricultural Experiment Stations (AES). The University of Florida and the CES, for example, are conducting intensive studies of fertilizer and pesticide movement in ground water under vegetable fields and citrus groves in the Florida DP. The Malheur County AES is evaluating irrigation and fertilizer management practices in the Oregon HUA project.

Finally, regional or local agencies are contributing to water quality monitoring in a

few projects. The Kosciusko County Health Department, for example, is conducting a monitoring program specifically in support of the Indiana HUA. In the Nebraska DP, several state Natural Resource Districts are monitoring the vadose zone on project area fields.

Water Quality Data Use and Management

Water quality data can be important to guide project management, target implementation, and evaluate progress if used and managed effectively. The effectiveness with which projects use and/or manage water quality data can be gauged by how data are presented, discussed, and evaluated and whether the data and evaluations are integrated into project reporting.

Good presentation and analysis of data have been rare among the Assessment projects. Half of the 16 projects presented some water quality data in their FY 1992 reports, but reports have provided little discussion or evaluation of available data. Only three projects integrated water quality data results into their evaluations to the extent that the results were useful in guiding or interpreting project progress; in these cases water quality data will help target land treatment efforts, assess treatment needs, and support recommendations for management systems.

The general weakness of water quality data use and analysis among the Assessment projects stems from inability to integrate water quality concerns into project plans and activities at the program level. Water quality information should not be treated as an isolated appendix to the land treatment program. Water quality data can and should be used to assess, guide, and fine-tune project activities. It is essential that project staff involved in land treatment also become involved in looking at water quality response. Neither land treatment nor water quality monitoring programs should take place in a vacuum; without significant interaction, both efforts are weakened.

Ability of Monitoring Networks to Detect Change

The primary purpose of water quality monitoring in this context is to detect change in response to treatment. With a few exceptions, it will be extremely difficult for the monitoring networks operating in the Assessment projects to detect and document changes in water quality. It will be more difficult still to attribute any changes observed to the land treatment program.

Among the projects, the ability of monitoring networks to detect response to land treatment is a function of many factors including:

- Specificity of the monitoring system.
- Monitoring design.
- Land treatment tracking.
- Nature of the hydrologic system and the impaired waterbody.

Monitoring systems that have been developed specifically in support of a project and its land treatment program obviously stand a much better chance of detecting changes in water quality than do monitoring networks with other objectives. Specifically designed monitoring programs are found in few projects. The California DP is an exception, where pesticide levels above and below three demonstration irrigation systems are being closely monitored to evaluate the ability of each systems to reduce tailwater pesticide residues. In the Michigan HUA, the paired watershed study was specifically designed to evaluate the impact of the Sycamore Creek project.

In contrast, even the extensive regional monitoring efforts that overlap some project areas are not likely to detect changes resulting from the project because sampling sites are not near areas of land treatment and because the goals of the ambient monitoring network are to characterize regional water quality patterns, not to detect localized changes.

Monitoring design is a fundamental determinant of ability to detect change. While collecting occasional grab samples may sometimes be adequate for inventory or assessment of regional water quality, effective monitoring for the purpose of detecting change must be carefully designed. Effective monitoring programs must:

- Evaluate variables and/or impairments expected to change following treatment.
- Be located near the impaired use and/or the treatment area.
- Be collected at enough locations with sufficient frequency to document the inherent variability of the system.
- Be capable of controlling for the inevitable variability in climate, season, and hydrology that tends to obscure the effects of treatment.

Monitoring efforts in two projects meet these criteria. In the California DP, a combination of above/below demonstration site monitoring with an established long-term trend monitoring network in the Sacramento River should be capable of detecting changes resulting from the DP. In the Michigan HUA, the use of a control (untreated) watershed in a paired-watershed design will account for hydrologic variability and should facilitate detection of water quality changes at the watershed level.

Monitoring programs that look only at the outlet of a treated watershed or that rely on before/after sampling without accounting for likely differences in year to year precipitation cannot detect and document water quality changes convincingly. Without the ability to control effectively for seasonal or year-to-year hydrologic variations, a monitoring program will be largely unable to attribute observed changes to land treatment.

The lack of accurate tracking of land treatment and absence of good information on agrichemical management can obscure the relationship between treatment and water quality response. Assumptions of nutrient reductions, for example, based on counting the number of nutrient management plans signed rather than on enumerating actual quantities of fertilizer applied provides little or no information about water quality protection to be expected. Such assumptions, if false, may lead to the erroneous conclusion that treatment was ineffective if no water quality response is observed.

The nature of the hydrologic system influences detection of water quality change. Long hydrologic lag times, such as very slow rates of ground-water movement, essentially prevent the detection of change in the project time frame. In one HUA, for example, an estimated 80-year time of travel in ground water between source areas and the impaired resource makes response to treatment unlikely within the project period. Similar lag times may affect surface water projects where large quantities of pollutants have accumulated in soils and sediments.

The relationship between the impaired waterbody and the land treatment area can also make detection of water quality change problematic. Monitoring in an impaired waterbody such as a reservoir, for example, is not likely to show a response when there are other major unmonitored sources of pollutants, when the project area contributes only a small proportion of the total water or pollutant load causing the water quality problem, or when the extent of treatment is small. Monitoring would be more effective pulled back up into the tributaries.

In summary, with a few exceptions, existing monitoring programs among the sixteen Assessment projects should not be expected to be highly effective in detecting changes in water quality. Most of the monitoring programs lack the specificity, design, land treatment tracking, and link to the impaired use to clearly document changes in water quality.

Results of Water Quality Monitoring and Evaluation

For the most part, there have been no significant water quality findings reported from the Assessment projects at this time. Even with appropriate monitoring, definitive results should not be expected in just three years. A few of the projects have presented good analyses of background water quality and problem definition which can serve as the basis for project impact assessment through continued monitoring.

Only in the California DP have water quality monitoring results documented response to treatment. Early monitoring efforts at demonstration sites have shown that the improved irrigation water management systems reduce potential pesticide discharge by 60 to 96 percent compared to conventional systems (UC Cooperative Extension, 1992).

Current Issues in Use of Monitoring to Assess Project Impacts

Direct assessment of project impacts through water quality monitoring will be difficult. Evaluation of monitoring activities among the 16 Assessment projects has revealed some common issues concerning use of monitoring for project evaluation. Some of these can be addressed in present projects; other issues are more fundamental and should be considered in the development of future projects:

- Failure to give water quality monitoring and evaluation adequate priority at the program level when project plans were formulated has resulted in reliance on outside agencies for monitoring work.

- As a consequence, the monitoring activities often have goals and capabilities poorly suited to project operation and evaluation. Monitoring, not surprisingly, is not well integrated into total project operation and management.
- As a result, water quality monitoring efforts in most of the sixteen Assessment projects suffer from one or more technical limitations in design and/or execution, including lack of adequate resources for operation, analysis, and interpretation; lack of specific focus on the project area or land treatment program; and lack of control for spatial and temporal variability.
- Some project areas are poorly suited for successful demonstration of water quality response to treatment in a realistic time frame due to large size of the project area, significant hydrologic lag time, or relatively small contribution to the targeted water quality impairment.
- Because of the above factors, water quality monitoring programs in most of the 16 projects are not likely to be capable of detecting and documenting water quality changes.
- Lack of emphasis on land treatment tracking, collection of agricultural management data, and documentation of actual levels of chemical use has impaired the ability of the projects to tie land treatment to water quality.

Recommendations for Future Monitoring Programs

Despite the current limitations discussed above, water quality monitoring can make significant contributions to watershed project evaluation. The key recommendation is that water quality monitoring and evaluation must be fully integrated into project planning, design, and operation. It should not be a separate effort by other agencies.

The following recommendations are presented to strengthen agricultural nonpoint source control programs and policies based on experiences of this case-study group of USDA water quality projects. While most of these recommendations are aimed at the program level, it is important to note that many of them deal with topics that are already part of the USDA guidelines. In such instances, the issue is to more aggressively provide technical and program direction and to support project staff.

- Project effectiveness and success should be evaluated primarily on the basis of achievement of water quality goals, and only secondarily on attainment of land treatment goals. Inventory of practices installed does not adequately reflect project impacts on improving or protecting water quality.
- Projects must state quantitative goals for improvement and/or protection of water quality. These goals should be directly related to background conditions of the impaired or threatened use and must be realistic and attainable.
- Projects must also set specific numerical goals for installation or adoption of specific land treatment practices and actual acres treated so that progress toward adequate treatment of pollutant sources can be documented. Data reported would be treated as a secondary indicator of reaching project goals.
- Land treatment and agricultural management activity must be tracked in detail, focusing on actual management activities like agrichemical application rates, not simply records of practices installed. Cost-effective and statistically reliable survey methods should be developed that reduce staff time required for land treatment data collection.
- Water quality monitoring to evaluate project impacts must be given adequate priority when project plans are formulated. This priority must begin at the program level and be carried through to the project level. Monitoring activities conducted outside the project mainstream, with goals and capabilities unsuited to the project, are likely to be ineffective in project evaluation.
- To be effective in assessing project impacts, water quality monitoring systems must be developed specifically in support of the project and must be designed appropriately, particularly with regard to the hydrologic system in the project area.

Some projects may consider designing a coordinated monitoring and simulation modeling network as part of a planned evaluation effort.

- Water quality monitoring data from the project must be presented, analyzed, and discussed as an integral part of project reporting and evaluation. Data should be presented and discussed in project reports and should be used, to the extent possible, to help target land treatment and assess interim progress.
- Funding agencies should improve institutional support for water quality and land treatment monitoring to provide better training and support systems for staff in project evaluation.

In some past land treatment/water quality projects, inadequate monitoring has yielded inconclusive or disappointing results, often leaving policy-makers and the public with the impression that land treat-ment is not capable of protecting or improving water quality. This group of USDA Demonstration Projects and Hydrologic Unit Area Projects is not likely to be an exception to this pattern. We must take the time to apply the lessons of the past that sometimes have been overlooked. While there are certainly cases where land treatment has not brought about major water quality improvements in a relatively short time, we must apply what we have learned from our exper-iences to design and implement effective monitoring programs in concert with water-shed management to document the successful achievement of water quality goals.

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Maryland's Targeted Watershed Project: Establishing Baseline Water Quality

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The Targeted Watershed Project is a multi-agency state initiative to improve water quality and restore living resources in several tributaries to the Chesapeake Bay. The project is using water quality and living resources monitoring programs to characterize water quality and living resources in the streams, guide restoration activities, and monitor effectiveness of these restoration activities.

The targeted watersheds are stream basins that are either threatened by multiple sources of degradation from urbanization or contribute a disproportionately high level of nutrients to the Chesapeake Bay from agricultural nonpoint sources. The watersheds are similar in size and small enough that measurable results are expected from the implementation of an array of nonpoint source pollution controls. In addition, citizen assistance via stream restoration projects and water quality monitoring is incorporated to help collect data and increase public awareness of watershed planning.

The project was set up in four phases. The first phase involved planning, initiating the project, and recruiting the cooperators. The second phase involved selecting the basins to be targeted. The third phase is the implementation of the control measures and the assessment of the project. The final phase of the project will involve reporting and disseminating the results.

The project is currently in its third year. The first two phases of the project are complete. Four basins have been targeted by the project: Sawmill Creek in Anne Arundel County, the Bird River in Baltimore County, the Piney/Alloway Creeks basin in Carroll County, and the German Branch basin in Queen Anne County (Figure 1). Sawmill Creek, a 5,440-acre sub-basin of the Patapsco River, is in an urbanized basin. Sawmill Creek suffers from elevated storm water flows that cause excessive channel erosion, the impacts of runoff from a major airport in the basin, and habitat degradation in the stream corridor. The Bird River, a 17,280-acre sub-basin of the Gunpowder River, is located in a rapidly urbanizing basin and suffers from high sediment loads, high storm water flows and excessive stream channel erosion, and habitat degradation. Piney/Alloway Creeks, a 31,040-acre sub-basin of the middle Potomac River, and German Branch, a 12,100-acre sub-basin of the Choptank River, are located in agricultural watersheds and suffer from excessive nutrient and sediment loads.

The project is currently in the assessment and implementation phase. Water quality and living resource assessment and monitoring plans and implementation plans have been developed in each of the watersheds. Restoration activities are focused on water quality problems identified by water quality data collected prior to the project or through the project's water quality assessment program.

The data being generated by the Targeted Watershed Project's water quality and living resource monitoring program are being used for several purposes:

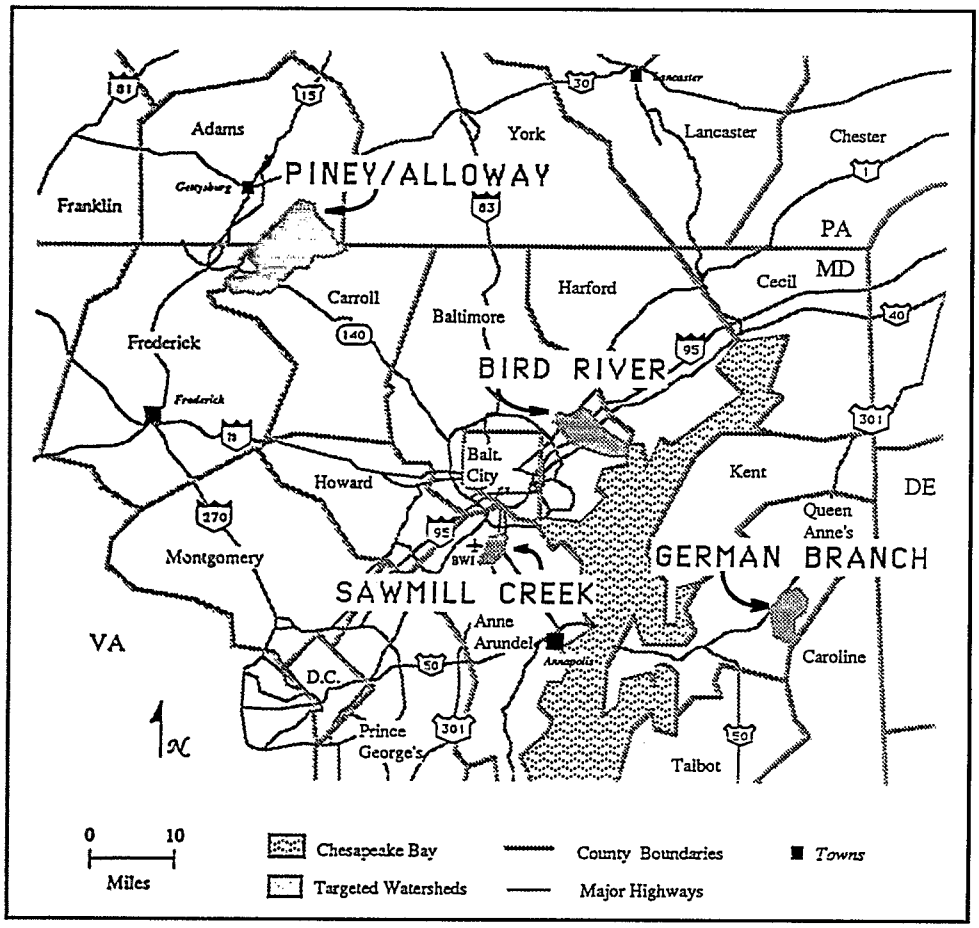

Figure 1. Maryland's targeted watersheds.

1. To establish baseline water quality and biotic conditions in the watersheds.
2. To estimate pollutant loads for each watershed.
3. To evaluate water quality trends in each watershed over time.
4. To detect any changes in biotic conditions in each watershed during the project.

Improvements in water quality and/or biotic conditions within each watershed relative to baseline conditions or as measured with a trend analysis are the measures of success for this project.

This paper will focus on the monitoring program used to establish baseline water quality conditions in each of the targeted watersheds.

Methods

The targeted watershed monitoring program was designed by a group of scientists and managers from various state, federal, and county agencies. The goal was to structure the monitoring program to be able to characterize water quality, habitat value and productivity of the streams that were to be managed. The project monitoring team agreed that the number of stations should be the minimum necessary to isolate major sources of pollution in the watersheds and yet not exceed the project's manpower and resource limitations. Monitoring stations were chosen to provide even area coverage on the mainstem of the stream and to characterize any major tributaries within each watershed (Figure 2). Nine monitoring sites were selected in the Sawmill Creek watershed. Six of the sites are on the mainstem and three are in major tributaries. Nine monitoring stations were selected in the Piney/ Alloway Creeks watershed. Three sites are on the mainstem of Alloway creek and five are on the mainstem of Piney Creek. There is one monitoring site located on a tributary of Piney Creek. Five monitoring stations were located in the German Branch watershed. Four of the stations are on the mainstem and one on a tributary. There are 10 monitoring stations in the Bird River watershed. The stations are located on three of the major tributaries of the Bird River.

The water quality assessment and monitoring plans have four components; finfish sampling, macroinvertabrate sampling, water quality sampling, and hydrologic characterization. The water quality sampling and hydrologic characterization can be further subdivided into two categories:

- Water quality samples collected manually during predominately baseflow conditions.
- Water quality samples collected by automated water quality sampling stations during stormflow conditions.

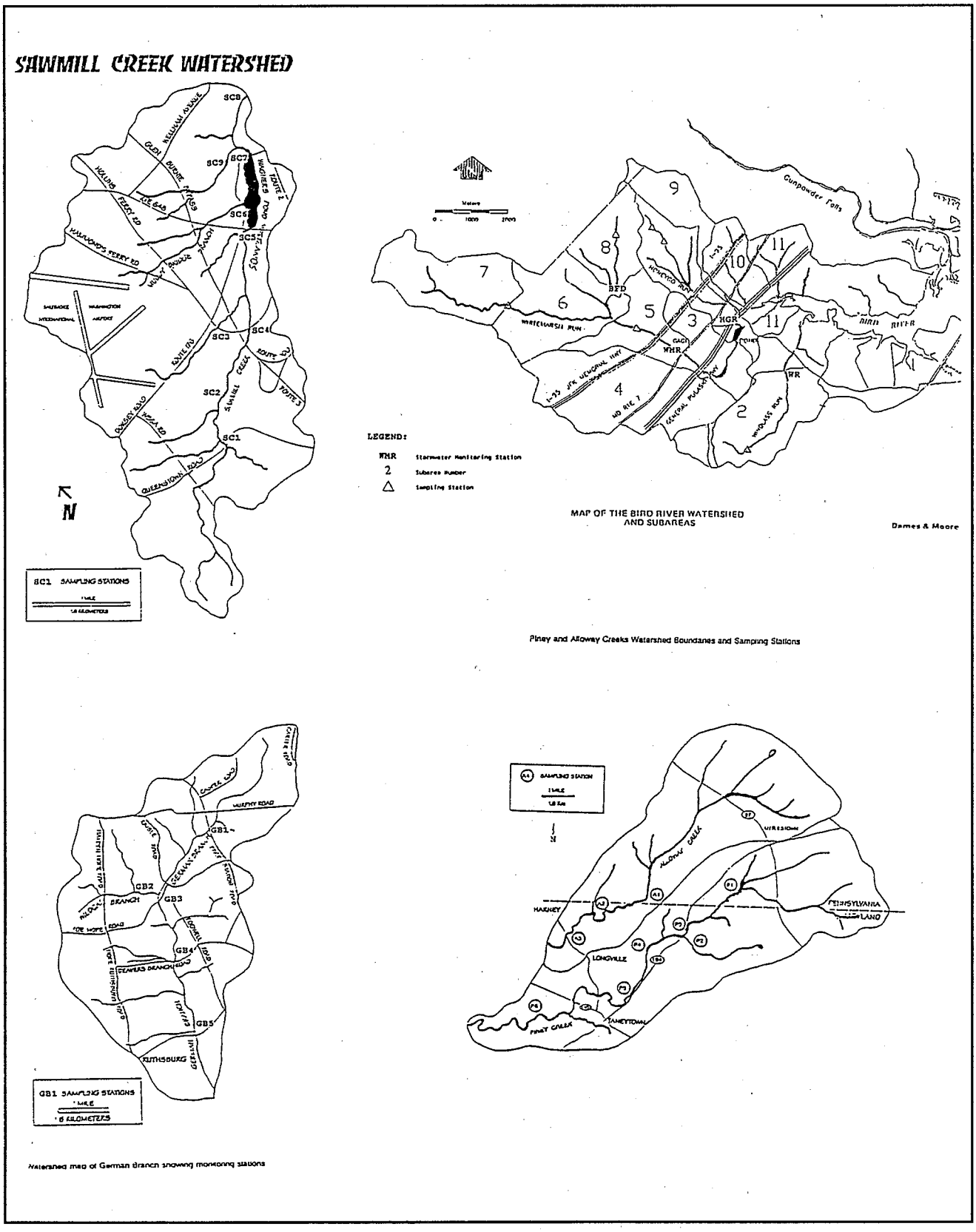

Figure 2. Targeted watershed sampling station maps.

Flow data can be similarly subdivided into two categories: flow data collected manually and flow data collected continuously by automated stations. Automated water quality sampling and discharge monitoring stations were established at the outlets of Piney Creek, Sawmill Creek, and German Branch. In the Bird River watershed, automated stations were installed at the outlets of Windlass Run, Honeygo Run, White Marsh Run, and at the outlet of the North Fork of White Marsh Run.

Hydrology

Staff gauges were installed at each sampling station in the Piney/Alloway Creeks watershed, the German Branch watershed, and the Sawmill Creek watershed. Flow measurements were taken periodically at each station by project staff using a portable Marsh/McBirney current velocity meter (Model 201D).

The U.S. Geological Survey (USGS) has been contracted to collect flow data continuously at the automated sampling stations in all four watersheds. The gauging stations were operated using USGS standard operating procedures (Buchanan and Somers, 1969; Rantz et al., 1982).

Water Quality

Water quality samples were collected monthly at each monitoring station in Piney/Alloway Creeks watershed, the German Branch watershed, and the Sawmill Creek watershed. Water quality samples in the Bird River watershed were collected biweekly at each station. Field measurements for temperature, dissolved oxygen, pH, and conductivity were made at each site with a Hydrolab Surveyor II. Discrete water quality samples were collected manually using standard sample handling techniques (Marshall et al., 1992). Samples were analyzed for the following constituents: total nitrogen, ammonium, nitrite, nitrate+nitrite, total phosphorus, orthophosphate, total suspended solids, hardness, sulfate, chloride, alkalinity, and silicate.

Storm event water quality samples were collected at the automated sampling stations in Piney Creek, Sawmill Creek, and the Bird River watershed as discrete samples taken at predetermined flow intervals over the storm hydrograph. Three discrete samples were retrieved from each storm: one discrete sample on the rising limb of the hydrograph; one at or near the peak; and one during the falling limb of the hydrograph. Storm event water quality samples were processed using the same procedure described above for the discrete monthly samples. Water quality samples from three to four storm events per quarter were collected at each automated station.

The Smithsonian Environmental Research Center was contracted to conduct the storm event based water quality monitoring at the outlet of German Branch. The storm event water quality data collected at the outlet of the German Branch watershed was collected as flow weighted weekly composites. The sample collection and preservation techniques used by the Smithsonian are described by Correll (1981).

Citizen Monitoring

Citizen monitors were recruited to conduct monitoring weekly at each station in Piney/Alloway Creeks watershed, the German Branch watershed, and the Sawmill Creek watershed. Citizen monitors used colorimetric test kits to test for dissolved oxygen, pH, and turbidity. The monitors also collected data on air temperature, water temperature, rainfall and, stage height. Citizen monitors are collecting benthic macroinvertabrate data in the Bird River watershed.

Toxicity

A suite of toxicity tests were conducted on several species of invertebrates and fish at each station in each watershed in Piney/Alloway Creeks watershed, the German Branch watershed and the Sawmill Creek watershed. The toxicity tests were conducted using U.S. Environmental Protection Agency (EPA) methods for testing effluents with some modifications to account for the use of ambient water (Peltier and Weber, 1985; Weber et al., 1989). Tests on *Pimephales promelas* (larval and embryo 7-day survival and 7-day growth), *Daphnia pulex* and *D. magna* (both 48-hour and 96-hour survival), and *Ceriodaphnia dubia* (7-day survival and neonate production) were conducted on 24-hour composite samples collected from all stations. In addition a "Microtox" bacterial luminescence assay was performed on samples from each station.

Benthic Macroinvertebrates

Benthic macroinvertebrate sampling was conducted at each station in Piney/ Alloway Creeks watershed, the German Branch watershed, and the Sawmill Creek watershed in the spring and fall according to EPA Protocol II Rapid Bioassessment Protocols (Plafkin et al., 1989). The procedure was modified as described by Marshall et al. (1992). The data were used to calculate an index of biological integrity (IBI).

In conjunction with the macroinvertabrate sampling, a habitat assessment was made. Various physical features of the adjacent watershed visible from the sampling site were scored, e.g., riparian zone, banks, and channel (Plafkin et al. 1989). The scores were used to develop a habitat assessment index (HAI). The HAI was used with the IBI to develop a relationship between habitat and the benthic community structure in the stream.

Finfish

Fish were collected during the spring and fall at each station in the German Branch, the Sawmill Creek, and the Piney/ Alloway Creeks watersheds, and at the four automated sampling sites in the Bird River. The finfish sampling procedures are described by Marshall et al. (1992)

The finfish data were used to calculate an IBI modified for use in Maryland's coastal plain streams (Fischer et al., 1992). The index was developed to assess biological quality in streams by measuring species composition, trophic composition, fish abundance, and health. In the piedmont streams species richness, trophic structure, and feeding strategies were used to evaluate conditions.

Results

The initiation of monitoring in each watershed was staggered over a period of time to allow for cooperator recruitment, station installation, and staffing. The reporting period for the baseline water quality data in each watershed covers approximately one year from the initiation of monitoring in the watershed. The German Branch and Sawmill Creek results were reported for the period October 1989 to September 1990. The Piney/Alloway Creeks results are reported for the period April 1990 to September 1991. The Targeted Watershed Project's water quality monitoring in the Bird River was not initiated until June 1992.

As part of the baseline water quality description, the monitoring program has developed chemical and physical constituent concentration profiles, toxicity assessments, habitat assessments, biotic indices for finfish and benthic macroinvertebrates, and annual loads for chemical and physical constituents of each stream . Given the volume of data generated by this process, it is not possible to present all of the results in this paper. Therefore, the results of the German Branch nutrient concentration profiles and annual loads for nutrients will be used as an example of the chemical and physical constituent concentration profiles developed for each stream. The highlights of the results from each baseline assessment will be discussed. The results of the habitat assessments, toxicity assessments, and biotic assessments for finfish and benthic macroinvertebrates have been compressed and summaries for the targeted watersheds are presented.

Water quality results were analyzed for differences in constituent concentrations between stations within each watershed (Figure 3). Significant differences in nutrient concentrations between stations were found in Alloway Creek, German Branch, and Sawmill Creek. Total nitrogen and nitrate nitrogen concentrations at the uppermost station on Alloway Creek were significantly higher than those at the other stations on the stream. In German Branch total nitrogen and nitrate nitrogen concentration in Wildcat Branch and in the mainstem down stream of Wildcat Branch were significantly higher than concentrations in the headwaters. Total nitrogen and nitrate nitrogen concentrations at tributary station 9 were significantly higher than concentrations at the other stations in Sawmill Creek. Overall, total nitrogen and total phosphorus concentrations were higher in German Branch and Piney/Alloway Creek than Sawmill Creek.

Constituent loads were estimated for Piney Creek and Sawmill Creek from the flow and concentration data collected at the automated sites using a "ratio estimator" (Dolan et al., 1981). Constituent loads in German Branch were calculated using the flow weighted weekly mean concentration and the total flow for the week (Table 1).

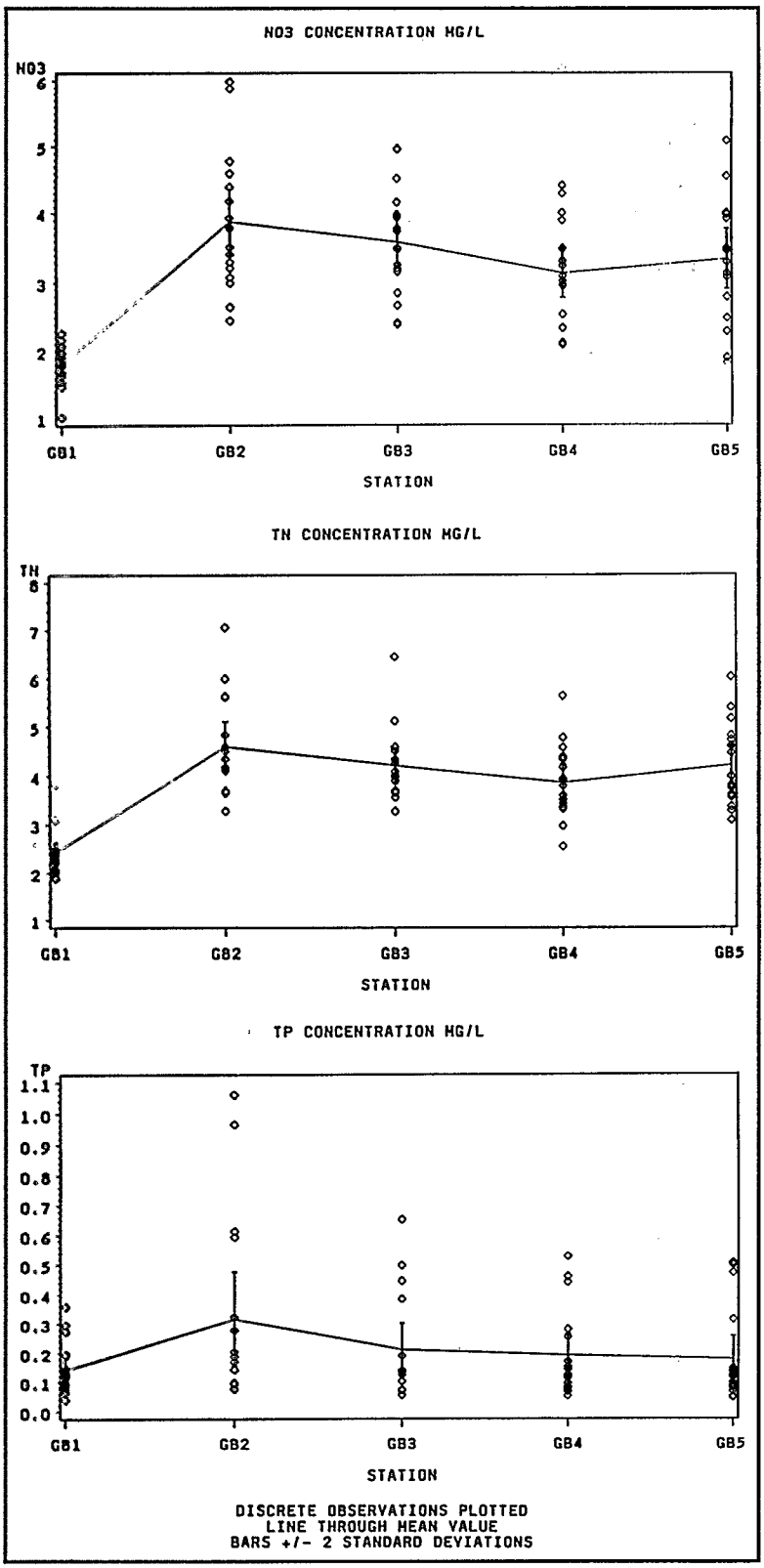

Figure 3. Nutrient concentrations in German Branch (October 1989-September 1990)

The loading estimates for TN (total nitrogen) and TP (total phosphorus) were used to calculate loading coefficients for each watershed (Table 2). When compared to loading coefficients reported in the literature, the targeted watershed's nutrient export rates for the baseline monitoring period were well within the reported range and close to the average reported values for agricultural and urban watersheds (Frink 1991).

Toxicity

The results of the ambient toxicity bioassays were analyzed for detrimental toxic responses (Table 3). Toxic responses were observed in Wildcat Branch, a tributary of German Branch, at the upper most stations of Piney and Alloway Creeks, and at most stations in Sawmill Creek. Two of the three tributary stations on Sawmill Creek, stations 3 and 6, yielded the most toxic responses. The toxicity bioassays were repeated with water samples collected during storm events in Sawmill Creek and Piney/Alloway Creeks. The results indicated that toxic responses increased in both streams during the rain events, but the same sampling sites yielded the most toxic responses. The toxicity bioassays were repeated for the Wildcat Branch, station 2, on German Branch during a rain event, and stations 3 and 6 on Sawmill Creek during ambient conditions. The water samples were fractionated for this assay into three components; whole water, water filtered for particulates, and water filtered for particulates and organic compounds. Significant reductions in the toxic response to the fraction that was filtered for particulates and organic compounds (over the whole water and the fraction filtered for particulates) indicates that organic compounds are contributing to the toxic conditions in both these streams.

Benthic Macroinvertebrates

The results of the habitat assessments and the IBI were plotted and used to make inferences about impacts on the benthic community (Figure 4). Stations with relatively high biological scores and relatively low habitat scores cluster near the upper left sector of the graph and suggest artificially induced enhancement of biological productivity may be present. Stations with relatively low biological scores and

relatively high habitat scores cluster in the lower right sector and suggest that water quality or other inconspicuous factors are impacting the benthic community.

The results of the benthic macroinvertebrate surveys indicates that German Branch and Piney/Alloway Creeks support healthier benthic communities and have better habitat than Sawmill Creek. German Branch, except station 2, and Piney Creek actually support healthier benthic communities than would be expected given their habitat scores. This may be due to elevated nutrient levels in the two streams. At station 2 in German Branch, the biological score is less than would be expected given the habitat score. This may be due to the toxic effect demonstrated by the toxicity assays. All of the stations at the lower end of Sawmill Creek had low biological and habitat scores.

Finfish

The results of the finfish surveys were used in conjunction with the habitat data to evaluate the condition of the finfish community in each stream. For all of the watersheds, species richness (number of species) and habitat quality were plotted for X-toxic response each station (Figure 5). Stations in the lower left portions of the graphs tend to be more degraded as far as habitat and fish community than stations in the upper right. Alloway Creek stations 1, 2, and 3 exhibited the best overall species richness and habitat, Sawmill Creek the worst. Other stations showed varying degrees of habitat

Table 1. Loads discharged by Piney Creek, Sawmill Creek, and German Branch 1990-1991 (mt/yr)

Constituent	Piney Creek	Sawmill Creek	German Branch
Total P	12.714	0.70	3.83
PO4	3.903	0.205	2.09
Org. Carbon	N.A.	N.A.	144.91
NO3	55.450	9.283	53.29
NH4	2.439	1.485	2.73
TKN	N.A.	N.A.	16.75
Sediment	3797.25	246.91	620.21
Total N	95.959[a]	16.135[a]	70.04[b]

[a] Analyzed as total N.
[b] Total N = (TKN + NO_3).
N.A. = Not analyzed/collected.

Table 2. Targeted watershed loading coefficients, 1990-1991 (kg/ha/yr)

Watershed	TP Loading Coefficient	TN Loading Coefficient
Sawmill Creek	.3375	7.998
Piney Creek	1.586	11.969
German Branch	.7367	13.4608

Table 3. Results of the ambient toxicity bioassays in Piney/Alloway Creeks, German Branch, and Sawmill Creek, 1989

Test	Endpoint	Piney Creek						Alloway Creek			German Branch					Sawmill Creek					
		P1	P2	P3	P4	P5	P6	A1	A2	A3	1	2	3	4	5	1	3	4	6	7	8
1. *D. magna*	Survival-48h																X				
	Survival-96h	X	X					X									X	X	X	X	X
2. *D. pulex*	Survival-48h																		X		
	Survival-96h	X	X				X	X									X		X		
3. *C. dubia*	Survival-7d																				
4. F. Minnow (L)	Survival-7d																X		X	X	
F. Minnow (E)	Survival-7d											X					X		X	X	X
5. F. Minnow (L)	Growth-7d											X				X	X	X	X	X	X
F. Minnow (E)	Growth-7d								X*			X							X		
6. *C. dubia*	Reproduction-7d			X*	X*		X*	X*	X*	X*											
7. Microtox	Luminosity-5min			X	X	X		X	X	X	X*			X*	X*						
	Luminosity-15min			X*			X*	X*	X*	X*	X*			X*	X*					X*	
Totals		2	2	1 (3)	1 (2)	1	1 (3)	3 (5)	1 (4)	1 (3)	0 (2)	3	0	0 (2)	0 (2)	1	6	2	7	4 (5)	3

L = larvae
E = embryos
X = toxic response
() = total responses, including enhancements
* = enhancement

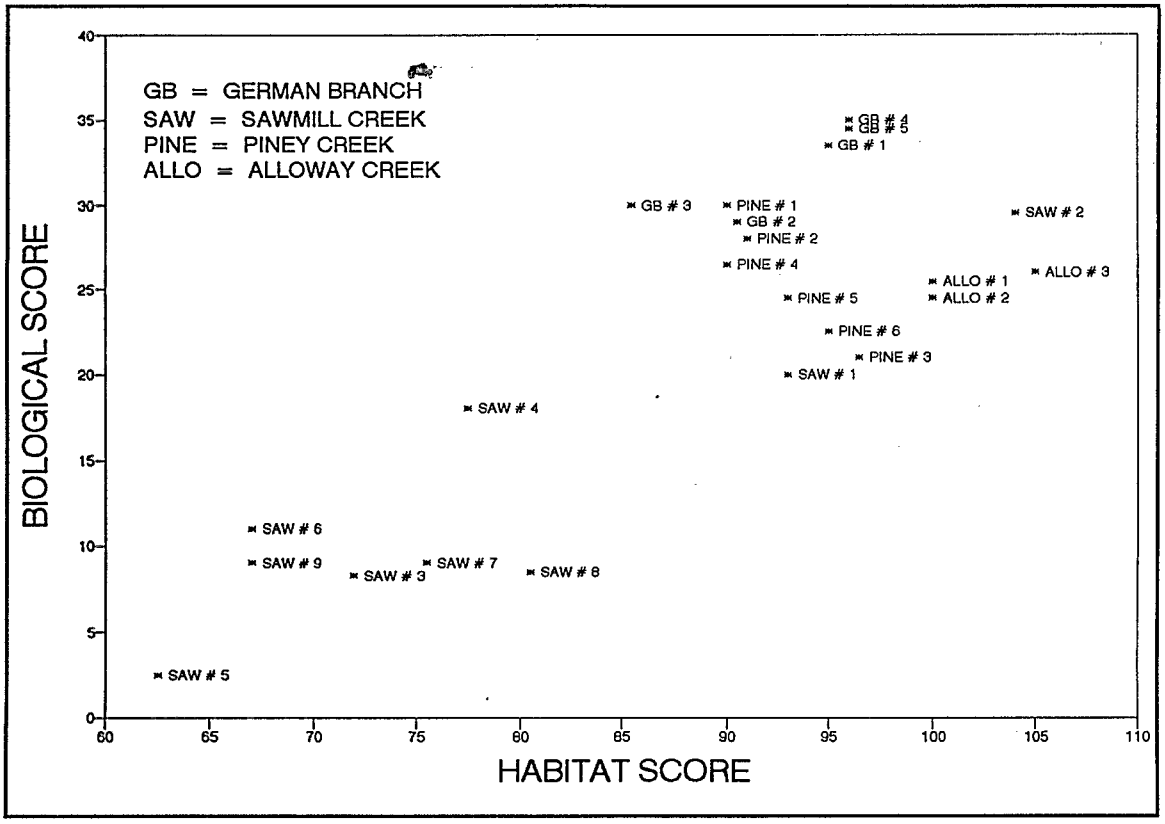

Figure 4. Results of the benthic macroinvertebrate surveys in Sawmill Creek, Piney/ Alloway Creeks, and German Branch, 1989-1990.

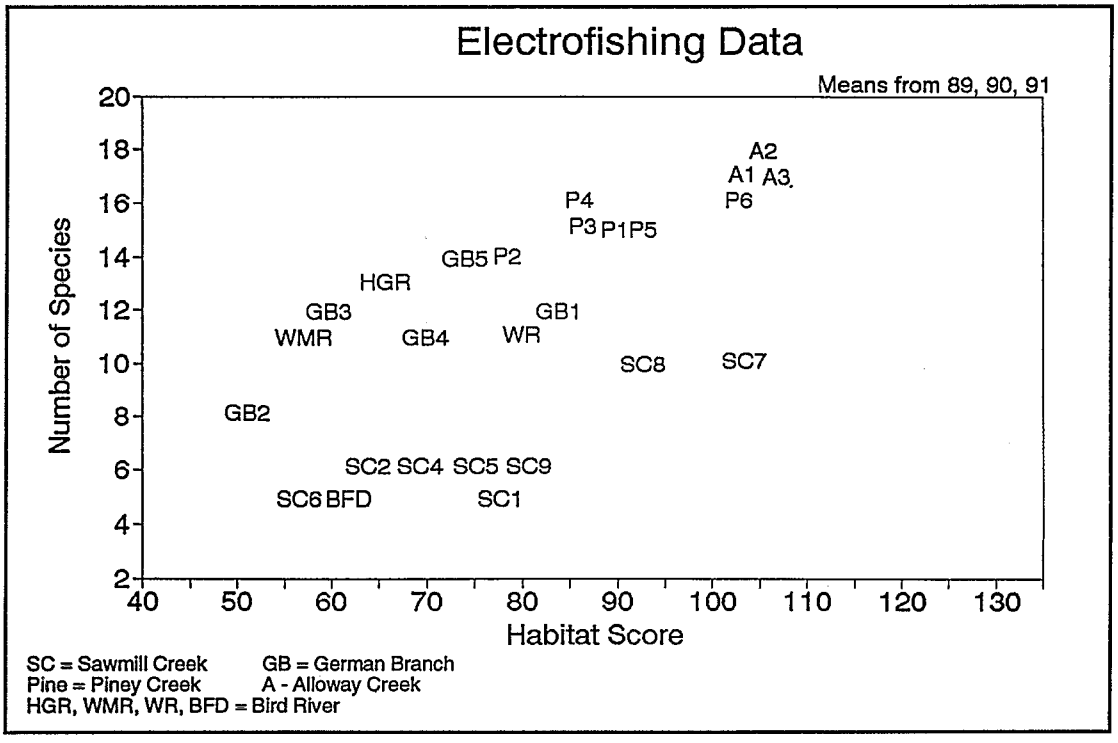

Figure 5. Results of the finfish surveys in all targeted watersheds, 1989-1991.

degradation or enrichment. German Branch, for example, had better fish diversity than would be expected given the poor habitat scores. This may be due to the higher levels of nutrients in this stream. Station 2 on Wildcat Branch exhibited the worst number of species and habitat scores in the German Branch system. Station 6 on Sawmill Creek had the worst number of species and habitat scores in the Sawmill Creek system.

Discussion

The data being generated by the monitoring program are being used to evaluate the effect of the restoration effort on water quality and habitat conditions. The results of the baseline water quality and living resources monitoring program suggest that Piney/Alloway Creeks and German Branch are nutrient-enriched systems. The restoration programs underway in Piney/Alloway Creeks and German Branch are targeting agricultural sources of nutrients to these streams. The Sawmill Creek system is the most degraded system of the targeted watersheds. Habitat appears to be the largest problem in the system. The restoration strategy that has been developed for Sawmill Creek is targeting storm water management as a means of restoring habitat to the system. The data suggest there is a toxicity problem at station 6 on Muddy Bridge Branch, a tributary of Sawmill Creek. Following an investigation of potential sources of toxicity on Muddy Bridge Branch and some anecdotal information, the project has begun monitoring the levels of airplane deicer in runoff from the Baltimore Washington International Airport and in Muddy Bridge Branch during winter storm events. The baseline data also suggest that station 2 on Wildcat Branch in the German Branch watershed was an impacted site. The toxicity bioassays indicated that the site exhibited toxic responses but did not isolate the cause. The biological data indicated that the finfish and benthic macroinvertabrate communities were impaired in Wildcat Branch. Nutrient loading data from the second year indicated that total phosphorus and orthophosphate loads increased 40 percent over the first year, and concentration profiles indicate that total phosphorus and orthophosphate levels in German Branch are the highest in Wildcat Branch. The project has begun to investigate the possibility that an agricultural operation on the tributary may be behaving as a point source and heavily influencing water quality in Wildcat Branch.

The baseline water quality and living resource monitoring program has developed a water quality and living resource database that will be used to determine the effect of the restoration programs under way in Piney/Alloway Creeks, German Branch, and Sawmill Creek. Continued monitoring will allow the project to measure changes in water quality and living resources that occur over time as a result of the restoration projects underway and to locate and identify new problems in water quality or living resources as they develop within each watershed.

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Watershed Project Monitoring and Evaluation Under Section 319 of the Clean Water Act

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Background

Monitoring to document water quality improvements that result from implementation of nonpoint source (NPS) control practices and practice systems is essential to continued public support for NPS control programs. The U.S. Environmental Protection Agency (EPA) annually awards state grants for implementing state NPS control programs under section 319 of the Clean Water Act, as amended in 1987.

To address the need to report on section 319 program implementation, progress made in reducing pollution from nonpoint sources, and water quality improvements resulting from program implementation, EPA issued guidance that called for monitoring in all funded watershed projects and established a 5 percent set-aside of grant funds for a "National Evaluation," hereafter referred to as the "National Monitoring Program" (USEPA, 1991a). EPA specified monitoring protocols for National Monitoring Program projects to provide a consistent, minimum set of water quality and land treatment data that would support a national evaluation (USEPA, 1991b).

This paper summarizes the requirements for National Monitoring Program projects and describes three of the approved projects. EPA's plans for analyzing data from the projects are also described and illustrated with examples.

Overview of National Monitoring Program Requirements

Selection Criteria

EPA selects projects for the National Monitoring Program based on their likelihood of achieving and documenting water quality improvements. The selection criteria include:

1. A clear documentation of water quality problems to be addressed.
2. Clear and concise water quality and land treatment objectives.
3. Project areas less than 30,000 acres.
4. A clear description of institutional roles and responsibilities.
5. A concise definition of critical areas.
6. A project implementation plan that includes NPS controls that address the identified water quality problems, pollutants, and sources.
7. A long-term (6-10 years minimum) monitoring and evaluation plan that includes tracking of both land treatment and water quality.
8. A quality assurance and quality control (QA/QC) plan (USEPA, 1991b).

Many of these requirements are based upon lessons learned from the Rural Clean Water

Program (USEPA, 1990; Gale et al., 1992) and related NPS programs.

Monitoring

The monitoring protocols focus on clear objectives and experimental approaches to achieving them. EPA recommends paired-watershed studies as the first choice for experimental design, followed by upstream-downstream designs. Single-station designs are discouraged. Lotic environments are emphasized since greater success in documenting the water quality benefits of NPS implementation has been achieved in stream systems.

Parameters

Chemical, physical, biological, and habitat monitoring programs are all acceptable under the National Monitoring Program, but minimum criteria are established for each. In addition to the specific reporting formats specified below, all raw water quality data are to be entered into STORET, BIOS, or WATSTORE.

For chemical monitoring, EPA has developed an approach that uses quartile values for each monitored parameter at each monitoring station (USEPA, 1991b.). These quartile values are computed from a frequency distribution of pre-project data or data from the first year of the project. Subsequent measured observations are compared against quartile values to determine which quartile the observations fall within. The number of observations that fall within each quartile is reported as the quartile count for the monitoring period (Figure 1). Trends in the distribution of quartile counts will be tested to indicate whether or not water quality has improved.

For biological and habitat data, EPA uses benchmark scores to provide for interpretation of index scores (USEPA, 1991b). For closed-end indices, such as the index of biotic integrity (IBI) (Karr, 1981), a maximum potential value (e.g., 60 for IBI) is recorded as the highest value that can be scored. For open-ended indices, such as the index of well being (Iwb) (Gammon, 1980), states are expected to use best professional judgment to estimate the highest possible score for the area. EPA recommends the use of data from reference sites (sites that reflect conditions in the area in the absence of environmental disturbance or impact) (Ohio EPA, 1988) to determine reasonable attainment levels and index values (expressed as percent) for various levels of beneficial use support. Observed values are then compared with benchmarks to determine percentages and the corresponding use support status.

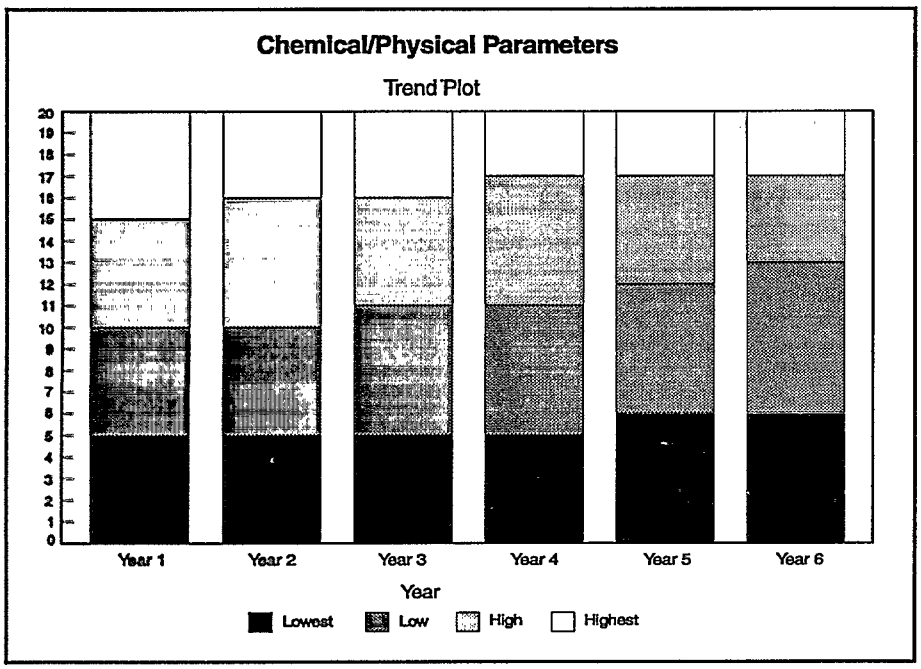

Figure 1. Bar charts illustrating quartile counts.

Sampling

Projects are expected to identify and focus monitoring efforts on those seasons or periods during which NPS impacts are greatest and for which the implementation of NPS controls is likely to cause the greatest impact. Water quality monitoring plans should cover 6-10 years, including at least 2-3 years of monitoring prior to implementation of NPS controls, and at least 3 years of monitoring after NPS controls are in place.

A minimum of 20 samples annually for chemical and physical parameters, evenly-spaced during the key season, is required. Fishery surveys are to be performed at least one to three times per season, while benthic macroinvertebrates are sampled at least once per season, with at least one to three replicates or

composites per sample. Bioassays can be performed once per season and habitat sampling should occur once or twice per season. Sampling frequency and sampling methods should remain unchanged throughout the monitoring effort.

Explanatory Variables

Since seasonal fluctuations are not the only source of variability in water quality data, explanatory variables are tracked to help account for variability in the values of primary monitoring parameters, thus increasing the sensitivity of statistical analyses by adjusting for climatic and hydrologic variability (USEPA, 1991c). Such variables may include flow, precipitation, changes in land use, and other water quality parameters (Spooner, 1992).

Land Treatment

Land treatment and land use monitoring are needed to quantify the status of land management. Appropriate land treatment parameters will indicate in quantitative terms the treatment strength (Spooner, 1992). Point sources, land use, and land activity must be monitored in watershed projects to account for their influence on water quality (Meals, 1991).

National Monitoring Program projects are to identify implementation goals for each best management practice or practice system to be used in the monitored watersheds, and relate these controls to the water quality problem, pollutants, and sources to be addressed (USEPA, 1991b). Point sources are to be avoided if possible, and otherwise monitored to determine their contributions to the water quality problems being tracked. Land treatment and land use are both tracked, and land treatment reporting units are expected to be reliable indicators of the extent to which the pollutant source is controlled. Distinct land treatment data must be collected for each drainage area served by a water quality monitoring station.

Testing of EPA's Protocol for Chemical and Physical Parameters

EPA's plan to track water quality trends using quartile counts was tested using 8 years of data collected at seven downstream (upstream-downstream pairs used) monitoring stations in the Rock Creek, ID Rural Clean Water Program project (NCSU, 1989). Only data collected during the irrigation season were analyzed. The results of applying the nonparametric Cochran-Mantel-Haenszel (CMH) statistics (SAS Institute, 1985) on the data summarized using EPA's quartile approach were compared with the results of parametric linear regression on the raw data.

Quartile ranges for each monitoring station were developed using the 25 percent, 50 percent, and 75 percent quartile values from the frequency distribution of observed values from the first year of monitoring at the station (Figure 2). The number of observed values for each irrigation season (year) that fell within each quartile was recorded as the quartile count for that station and year. Quartile cutoffs were unique to each station but did not change over time.

In the first comparison, downstream suspended sediment concentrations were regressed against time ("year" variable) for the parametric test (column A in Table 1), while for the CMH nonparametric test the relative frequency of counts in each quartile was correlated with "year" in a test of linear association (column D). The significance levels of the tests of linear trends were similar for the two approaches, but the correlation coefficient was larger in all cases in the parametric test (column C versus column F).

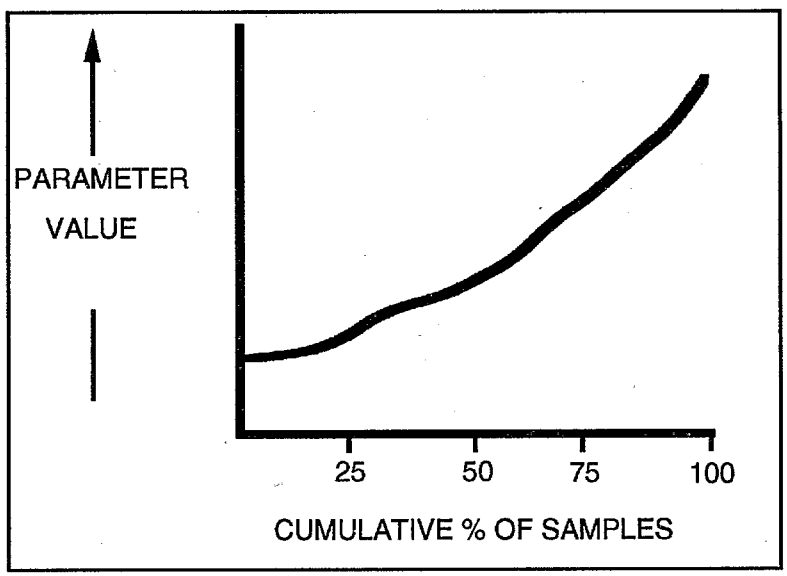

Figure 2. Cumulative frequency distribution.

Table 1. Comparison of linear trend detection using analysis of covariance on raw data versus using CMH statistics on frequency count data

		Analysis of Covariance on Raw Data			CMH Statistics on Quartile Data		
		A	B	C	D	E	F
Monitoring Station	Percent Change Observed over 8 Years[a]	Significance of linear trend (no covariate)[b]	Significance of linear trend (with upstream concentration as covariate)[b]	r (linear trend with no covariate)	Significance of CMH correlation (no covariate)[b]	Significance of CMH correlation (with upstream concentration as covariate)[b]	r (CMH correlation with no covariate)
1-2	-22	**	NS	-.47	**	*	-.32
2-2	-62	**	**	-.54	**	**	-.46
4-2	-77	*	*	-.60	**	**	-.42
4-3	-83	+	**	-.56	**	**	-.25
5-2	-74	*	*	-.54	**	**	-.33
7-4	+35	NS	NS	-.59	NS	NS	-.08
S-2	+15	*	NS	-.54	*	*	-.27

[a] Change versus average concentration for upstream station pair during 1981-1988 (1983 to 1988 for Station S-2).
[b] NS = No statistical evidence of a linear trend.
+ = There is evidence of a linear trend at the 90 percent confidence level.
* = There is evidence of a linear trend at the 95 percent confidence level.
** = There is evidence of a linear trend at the 99 percent confidence level.

In the second comparison, paired upstream suspended sediment concentrations were used as covariates in the parametric (column B) and nonparametric (column E) tests. Again, the conclusions that can be drawn from the two approaches are similar, but the significance levels are different. The CMH correlation statistic (column E) yielded a higher significance level for four of the seven stations, while in three cases the significance levels were the same.

In conclusion, EPA's quartile approach was determined to be applicable to the assessment of trends in water quality for the National Monitoring Program. Specific recommendations were made regarding the protocol, including the suggestion that statistical test results using quartile counts be considered preliminary, to be supported by detailed analyses of raw data.

Software Support for National Monitoring Program Projects

EPA developed the NonPoint Source Management System (NPSMS) software program to facilitate the standardized information tracking and reporting established for National Monitoring Program projects (USEPA, 1991b). This software has three data files:

1. The Management File, which includes information regarding project implementation plans and water quality problems within the project area.
2. The Monitoring Plan File, which includes the experimental design, monitoring stations and parameters, monitoring seasons, quartile values for chemical and physical parameters, and reference values for biological and habitat parameters.
3. The Annual Report File, which contains annual implementation and water quality data.

A series of standard reports and graphics can also be generated from NPSMS.

Currently Approved Projects

EPA has approved five projects to date—the Sny Magill watershed project in Clayton County, IA; the Elm Creek project in Webster, County, NE; the Long Creek project in Gaston County, NC; the Sycamore Creek project in Ingham County, MI; and the Morro Bay project in San Luis Obispo County, CA. EPA has also included a pilot ground-water project in the Snake River Plain of south-central Idaho. Three of these projects are summarized below, with key

aspects highlighted. These three projects are also profiled by Osmond et al. (1991).

Sny Magill, IA

Identification of Water Quality Problems

Sny Magill watershed covers 22,780 acres and includes Sny Magill and North Cedar creeks, which are both coldwater streams managed for "put and take" trout fishing. They are both classified as high-quality waters, but currently only partially support wildlife, fish, semi-aquatic life, and secondary aquatic uses. Problems are primarily due to agricultural nonpoint sources, particularly sediment, nutrients, pesticides, and animal waste.

Sny Magill watershed is entirely agricultural with no significant point sources. Cropland (42 percent), pasture (32 percent), and forest (23 percent) are the major land uses. Half of the cropland is typically in corn, with the rest primarily oats and alfalfa in rotation with corn. There are about 140 producers, with farm sizes averaging 275 acres.

Implementation Plan

The project is planned for 8 to 10 years. A U.S. Department of Agriculture (USDA) Hydrologic Unit Area (HUA) project covers 19,560 acres (86 percent) of the Sny Magill watershed. The remaining area is included in the North Cedar Creek Watershed Agricultural Conservation Program (ACP)—Water Quality Special Project (WQSP), which began in 1988.

Excessive sheet and rill erosion occurs on 4,700 acres of cropland and 1,600 acres of pasture. Gully erosion problems have been identified at 60 locations. Over 30 livestock facilities need improved runoff control and manure management systems. Grazing management is needed on over 750 acres of pasture and 880 acres of grazed woodland. A mile or more of stream corridor is in need of cattle exclusion or riparian repair.

The overall plan is to reduce sediment delivery by 50 percent. A 90 percent participation rate is expected. Fertilizer and pesticide inputs are expected to be reduced by more than 25 percent. Approximately 100 water and sediment and control basins are planned to address the gully erosion problems.

Monitoring Plan

A paired watershed approach is being used with the adjacent Bloody Run Creek watershed (24,064 acres) serving as the control with Sny Magill Creek as the study watershed. These watersheds are similar in size, ground-water hydrogeology, and surface hydrology. Available nitrate data indicate that the watersheds respond similarly to precipitation events. Sub-basins within the Sny Magill watershed will be compared using upstream-downstream studies.

Suspended sediment, discharge, nitrogen forms, total phosphorus, fecal coliform bacteria, and a few other standard chemical and physical parameters will be tracked. In addition, habitat assessments, fisheries surveys, and benthic macro-invertebrate sampling will also occur.

Implementation will be tracked through a coordinated process with the Soil Conservation Service and Cooperative Extension Service (CES).

Long Creek, NC

Identification of Water Quality Problems

Long Creek, the primary water supply for Bessemer City, is impaired by sediment, bacteria, and nutrients. Frequent dredging is required near the water supply intake and habitat is degraded downstream from the intake. Fishing and contact recreation on the portion of Long Creek within the project area are listed as threatened uses by the State of North Carolina. Agricultural activities related to crop and dairy production in the 28,480-acre watershed are believed to be the major nonpoint sources causing these problems. Watershed land uses are 53 percent forest, 25 percent agriculture, 19 percent urban, 2 percent mining, and 1 percent construction.

Implementation Plan

To achieve the water quality objectives for this 10-year project, it is estimated that a 60 percent reduction in sediment, a 50 percent reduction in nutrients, and reductions in bacteria levels are needed. The principal measures to be implemented are a range of agricultural practices, including animal waste management, permanent vegetative cover, conservation systems,

diversions, stream protection, nutrient management, pest management, woodland improvement, and sediment retention structures. Additional measures will include erosion and sediment control for forestry, storm water retention for urban sources, vegetated buffers and silt fencing for construction, septic system management and reduced lawn/garden chemical use for residential areas, and proper disposal of household hazardous waste.

Monitoring Plan

Three designs are proposed: paired, upstream-downstream, and single-station. Rainfall will be monitored at two locations in the watershed. One single-station study will take place at the water supply intake below cropland where runoff and erosion controls will be implemented. In accordance with the North Carolina Water Supply Protection Act, strict land use requirements will be imposed on land within one-half mile of the intake. Weekly grab sampling from December through May will be conducted, as will occasional storm event sampling. Parameters include suspended sediment (SS), temperature, conductivity, dissolved oxygen (DO), pH, turbidity, and flow.

The effects of improved waste management, nutrient management, and grazing management will be evaluated with upstream-downstream monitoring on Long Creek. Weekly grab sampling from December through May is planned. Parameters include coliform bacteria, DO, total suspended solids (TSS), phosphorus, nitrogen, and flow.

The paired study involves erosion control and nutrient management on cropland. Storm-event monitoring will be performed, with samples analyzed for flow, SS, nitrogen, and phosphorus.

Land treatment and land use tracking will be based on a combination of voluntary farmer record-keeping and frequent farm visits by CES personnel. Data will be stored and managed in a geographic information system (GIS) located at the county CES office.

Sycamore Creek, MI

Identification of Water Quality Problems

Water quality problems in the 67,740-acre watershed are caused primarily by sediment, and include habitat destruction, impaired macroinvertebrate communities, and dissolved oxygen standard violations. Based upon sampling, surveys, and modeling, the major sediment sources are reported to be agriculture (most of 34.2 percent nonurban), streambanks (36.8 percent), and urban (29.0 percent). The watershed is a USDA hydrologic unit project.

Monitoring and Implementation

The paired-watershed approach will be used. Haines Drain (848 acres) received most of its best management practices (BMPs) before 1990 and will be the control watershed since few additional BMPs are expected there. Willow Creek (1,087 acres) and Marshall Drain (422 acres) will be the study watersheds. Implementation plans for Willow Creek are to control erosion, nutrients, and pesticides on cropland and hayland; control erosion from urban areas; and control channel erosion problems. The full benefits of these control efforts are not expected to be measured until 1996. Implementation in Marshall Drain will consist primarily of erosion, nutrient, and pesticide control on cropland, hayland, and pasture.

Analysis of data collected between April 1990 and May 1991 shows strong associations between the TSS loadings of Haines Drain and both Willow Creek and Marshall Drain (Table 2). Plots of TSS concentration data for storm events show that Willow Creek has higher concentrations than Haines Drain, but that Haines Drain has higher concentrations than Marshall Drain (Michigan DNR, 1992). Table 2 also illustrates similar base and peak flow between the study and control watersheds.

The sampling season is from March through July, and monitoring parameters include TSS, turbidity, nutrients, and chemical oxygen demand (COD); with continuous flow, total rainfall, and the erosion intensity index as covariates. Runoff samples (6-12 per storm) will be collected for at least 4 runoff events (load and runoff volume), and weekly sampling will provide at least 20 samples per year.

Field reconnaissance will be used to track land use and land cover in each watershed. AGNPS (agricultural nonpoint source pollution model; Young et al., 1985) data cells (10-acre cells) will be used for tracking the information.

Table 2. Correlation analysis for total suspended solids loads and flow parameters

	Willow Creek TSS Load	Marshall Drain TSS Load	Willow Creek Base Flow	Marshall Drain Base Flow	Willow Creek Peak Flow	Marshall Drain Peak Flow
Haines Drain TSS Load	0.79** (n=9)	0.81** (n=9)				
Haines Drain Base Flow			0.55* (n=13)	0.70* (n=10)		
Haines Drain Peak Flow					0.76** (n=13)	0.65* (n=10)

* Pearson Correlation Coefficient significant at 95 percent confidence level.
** Pearson Correlation Coefficient significant at 99 percent confidence level.

Future

EPA anticipates approving a total of 20 to 35 National Monitoring Program projects if resources allow. The Agency is currently exploring the potential for developing ground-water monitoring protocols for the program and hopes to eventually address monitoring in lakes, estuaries, and coastal waters as well. Much work lies ahead, however, before these goals can be achieved.

Data from the existing projects will be reported annually to EPA, and EPA will develop annual reports that incorporate the findings of North Carolina State University and Oregon State University, which are both under grants to perform watershed project studies. Annual workshops will be planned to provide assistance to projects. The first workshop is scheduled for September 13-16, 1993, in Gaston County, NC, and will be hosted by the Long Creek project.

Summary

EPA has developed and tested monitoring protocols to be applied in a subset of NPS watershed projects nationwide for the purpose of providing consistent data from which conclusions can be drawn regarding the success of implementation under section 319 of the Clean Water Act. Five projects are currently in the National Monitoring Program, and EPA seeks an additional 15 to 30 projects.

Projects in Iowa, North Carolina, and Michigan were summarized to illustrate the approaches taken to meet EPA's program criteria. All three projects have incorporated paired-watershed studies as a key component. Upstream-downstream studies are also being conducted. Land treatment is being collected and recorded in a variety of ways, including farmer record-keeping and GIS.

The section 319 National Monitoring Program is in its nascent stage. EPA, however, has high expectations that the projects included in the program will demonstrate water quality improvements resulting from land treatment efforts.

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Multidisciplinary Approach to Nonpoint Source Nutrient Control

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Lake Okeechobee is an 1,891-square-kilometer (730-square-mile) multiuse lake located in south central Florida and is the second largest lake within the continental United States. It provides South Florida residents with many beneficial uses such as municipal water supply, agricultural irrigation, cooling water for power generation, recreational activities, and a large sport and commercial fishing industry. It is also the home of many species of fish and wildlife, including species listed as threatened or endangered by the U.S. Fish and Wildlife Service.

The dominant land use in the region is agriculture, which includes dairy, beef, truck crops, sod, nursery, hog, sugarcane, and citrus. The supporting industries include fertilizer, feed, and heavy equipment subsidiaries. The largest sources of net phosphorus imports to the basin are feed and fertilizer (Fonyo et al., 1991).

Topography of this region ranges from 23 meters (75 feet) National Geodetic Vertical Datum (NGVD) at the basin headwaters to 5 meters (18 feet) NGVD at the lake. The soils are poorly drained sandy spodosols that have a wet season average depth to water table within 0.3 meter (1 foot) of the surface. These soils typically have a high potential for phosphorus transport. In those areas where organic soils are dominant, drainage practices can result in soil oxidation and subsequent nutrient transport.

Average annual rainfall for the region is approximately 127 centimeters (50 inches), most of which occurs during the summer rainy season from June through October. Rainfall is the primary source of water to the lake. Other sources include the Kissimmee River and surface runoff from 40 other tributary basins (Figure 1). Primary outlets are evapotranspiration and a series of canals that convey water to the lower east coast (Miami-Ft. Lauderdale area) and on the west coast, the Caloosahatchee estuary near Fort Myers. Gate structures control all inflows and outlets to the lake except one inflow tributary, Fisheating Creek. Structures and conveyance canals leading to and from the lake are the heart of a regional Central and Southern Florida Flood Control Project, a congressionally authorized public works project built by the U.S. Army Corps of Engineers under the local sponsorship of the then Central and Southern Florida Flood Control District. That agency is now the South Florida Water Management District (SFWMD), one of five regional resource management agencies created by the State of Florida and charged with the preservation, protection, and management of the region's water resources.

The objectives of this paper are to examine three resource management strategies directed at controlling phosphorus discharges from intensive agricultural land uses located north of the lake and to briefly discuss the coordination and communication among experts from various internal SFWMD line management

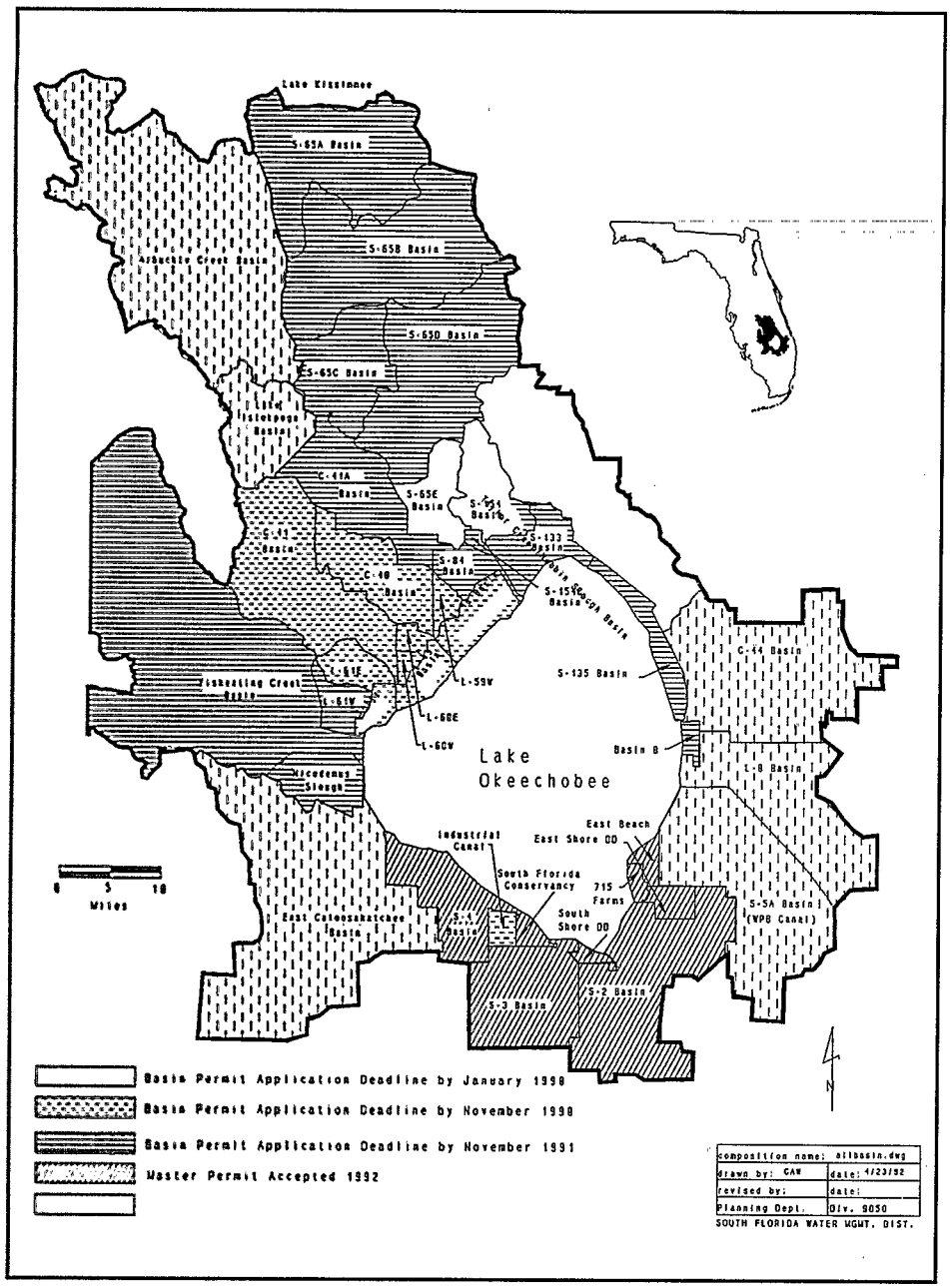

Figure 1. Lake Okeechobee SWIM priority basins.

Resource Direction

As a regional water resource management agency of the State of Florida, the mission statement of the SFWMD includes water quality, water supply, environmental enhancement, environmental protection, and flood protection issues for south Florida including the Kissimmee River, Lake Okeechobee, and Everglades system. During the past 20 years, some beneficial uses of Lake Okeechobee have become threatened due to excessive nutrients, especially phosphorus, entering the lake tributary sources. In response to declining water quality conditions, both within the lake and the surrounding drainage basins, the SFWMD sponsored a number of research/demonstration projects. The focus of these environmental studies, dating from 1971, was Lake Okeechobee and the surrounding basins (Joyner, 1971; MacGill et al., 1976). The SFWMD has been conducting follow-up studies on the lake and tributary sources since 1973 addressing issues such as in-lake dynamics (Davis and Marshall, 1975; Marshall, 1977), the modification of Vollenweider's nutrient loading model to establish maximum phosphorus loading rates to the lake (Federico et al., 1981), and the identification and quantification of major sources of agricultural nonpoint source nutrient runoff (Ritter and Allen, 1982; Goldstein, 1986). More recently the Rural Clean Waters Program for the Taylor Creek/Nubbin Slough basin, tributary to the lake, focused on the evaluation of the effectiveness of Best Management Practices (BMPs) (Flaig and Ritter, 1989; Gunsalus et al., 1992).

In 1986, a select panel of scientists and agricultural industry representatives formed the Lake Okeechobee Technical

departments (Water Resource Evaluation, Research, Planning and Regulation) and external agencies needed to carry out these regional phosphorus control strategies (Soil Conservation Service (SCS), Department of Agricultural and Consumer Services, Florida Department of Environmental Regulation (FDER), University of Florida Institute of Food and Agricultural Sciences, and County Extension Service).

Advisory Committee (LOTAC) to review this body of research. The available scientific information generated from these projects concluded that excessive nutrient inputs are being generated from agricultural land use activities. LOTAC identified dairies and other intensive animal use operations as the primary source of phosphorus inflow to the lake and recommended a series of water management actions to control or reduce these nutrient sources (LOTAC, 1986; LOTAC II, 1988).

In response, the Governor initiated the first management strategy by directing the FDER to develop and implement a "Dairy Rule" to regulate the control and treatment of animal wastes generated from the dairy industry located within the Lake Okeechobee drainage basins.

Secondly, the Florida legislature passed the Surface Water Improvement and Management (SWIM) Act (Chapter 373.451-373.4595 F.S.) in 1987 that directed the state's five Water Management Districts to identify, develop, and implement resource management plans for restoration and protection of priority waterbodies throughout the state (Figure 2). Given the high level of concern for Lake Okeechobee a specific element of the legislation was the development of phosphorus control targets for the lake, a major objective for the SFWMD. In 1989, the SFWMD completed the interim Lake Okeechobee SWIM plan (SFWMD, 1989; SFWMD, 1993). The resource management goal for the first phase of this plan was to reduce the phosphorus load to the Lake by approximately 40 percent. Fifteen of the 41 basins that make up the SWIM planning area for Lake Okeechobee were identified as priority basins. These basins were targeted based on the severity of their historical total phosphorus load to the lake and represent a drainage area of approximately 3,298 square kilometers (1,273 square miles) or roughly 75 percent of the total drainage from the northern area of the Lake.

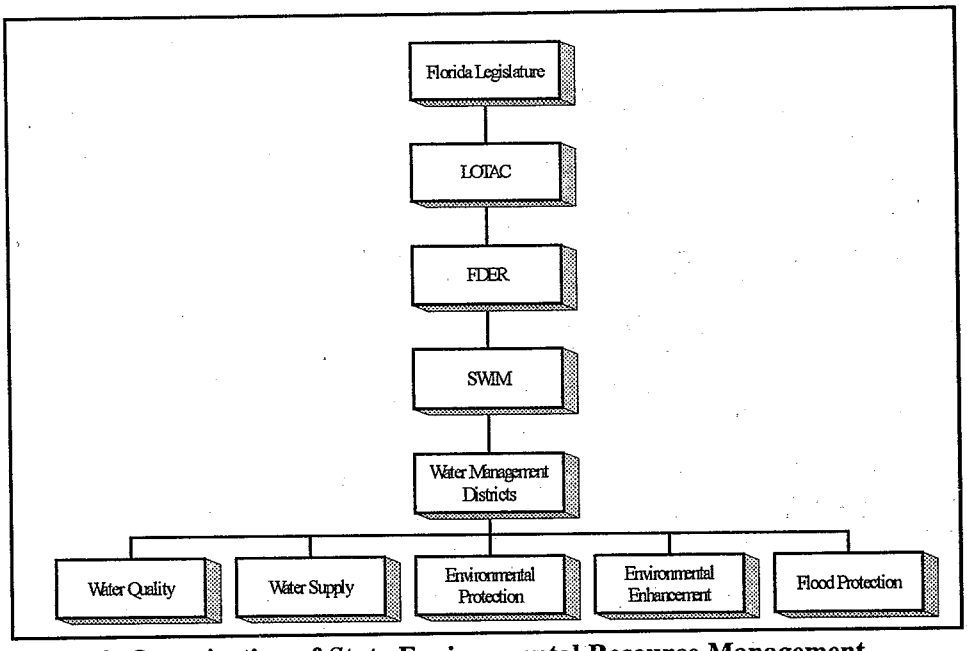

Figure 2. Organization of State Environmental Resource Management Strategy.

Resource Management Strategy

The SWIM plan called for three primary phosphorus control strategies directed at reducing phosphorus imports and subsequently reducing basin phosphorus loads. These strategies are the FDER Dairy Rule BMPs, a Dairy Buy-Out program, and the regulation of nonpoint sources of runoff, from nondairy land uses, through the Works of the District Rule 40E-61, Florida Administrative Code (Figure 3). Regulation of the FDER Dairy Rule program is based on the management of specific BMPs rather than the performance of the designed technology in achieving regional phosphorus targets. The Dairy Buy-Out, and Works of the District, Rule 40E-61 programs represent a major shift in the SFWMD's lake management strategy from an emphasis on technology-based research and demonstration support to one of performance and regulation-based resource management (Figure 4). However, SWIM phosphorus targets are used as an index to measure the effectiveness of the Dairy Rule program.

The goal of each of these programs is to reduce the phosphorus load entering the lake from agricultural nonpoint source runoff. The FDER and the SFWMD are

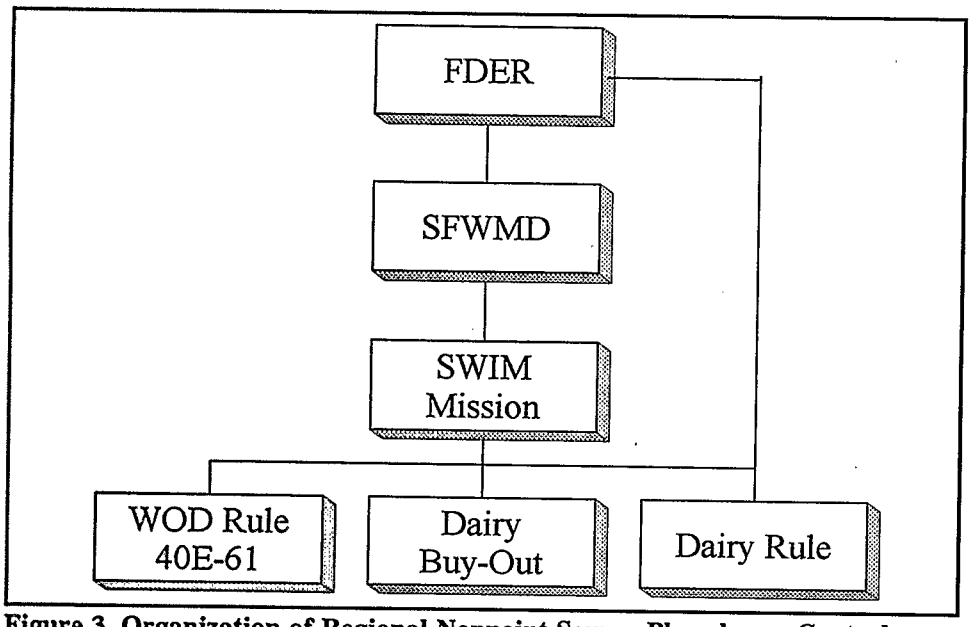

Figure 3. Organization of Regional Nonpoint Source Phosphorus Control Strategies.

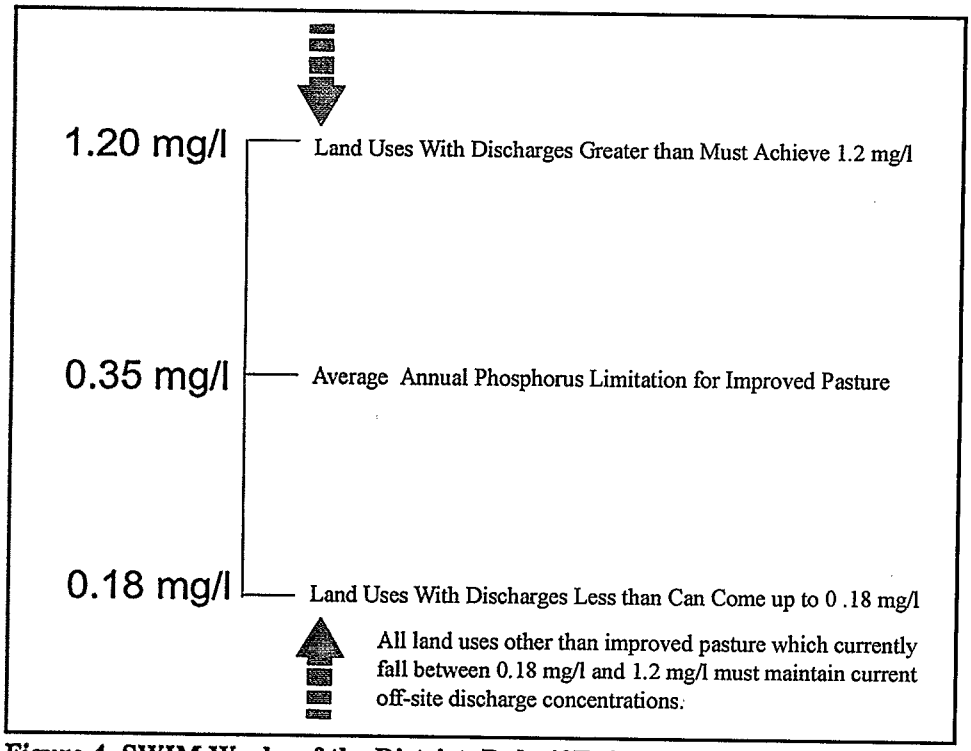

Figure 4. SWIM Works of the District, Rule 40E-61 Phosphorus Concentration Standards.

committed to these programs through the coordinated utilization of various disciplines to perform support for administration, data collection, data assessment, technology evaluation, model development, and program assessment efforts.

FDER Dairy Rule

The FDER Dairy Rule was promulgated in 1987. It required all dairies in the Lake Okeechobee basin to implement BMPs designed to reduce nonpoint source runoff from the high intensity area around the milking barn. Best available information indicates that by reducing on-farm phosphorus discharges, from the high-intensity area, to no greater than 1.2 milligrams/liter (mg/l), coupled with the reduction in phosphorus imports achieved through the Dairy Buy-Out and the Works of the District programs, the assimilative capacity of the basin would provide enough nutrient uptake necessary to achieve the average annual phosphorus discharge target of 0.18 mg/l at the basin outfall structures to the lake.

Dairy Rule BMPs are designed to capture and collect all runoff from the high intensity areas around the milking barn and then recycle this nutrient enriched water for reuse on forage pastures through center pivot irrigation systems. The system is designed to reduce the amount of phosphorus in surface runoff from the farm as well as provide a mechanism for water management and water conservation through water retention and reuse. Engineers from SCS and two private consulting firms, hired by the SFWMD, designed and provided construction supervision for all 30 farms participating in the Dairy Rule program.

The SFWMD is responsible for the water quality monitoring and evaluation of this program. Information is disseminated through regular coordination and communication between the FDER, the SFWMD, and local dairy operators. In addition, the University of Florida Institute

of Food and Agricultural Science, in conjunction with county Agricultural Extension Agents, and the SFWMD are working together to design and develop computer models to optimize nutrient management strategies for each farm. The SFWMD is providing pre- and post- Dairy Rule water quality monitoring data in support of this effort.

Dairy Buy-Out Program

The purpose of the Dairy Buy-Out program, initiated in 1989 by the Florida Department of Agriculture and Consumer Services and the SFWMD, was to provide an economic option to dairy owners who were unable to or chose not to comply with the FDER Dairy Rule. The Agency rationale was that removal of the cows from the basin also eliminated phosphorus imports into the basin. Eighteen dairies participated in this program, which required the removal of all dairy milk herds and suspension of all dairy milking activities on the property. Implementation of alternative land use practices subsequent to the program required compliance with appropriate average annual phosphorus discharge limitations consistent with Works of the District, Rule 40E-61.

The Water Resources and Evaluation Department of the SFWMD is responsible for the data collection in support of a regulatory compliance based water quality monitoring program on those Buy-Out farms that converted to another animal intensive operation. Water quality monitoring data are being evaluated by the SFWMD to determine the effectiveness of the Dairy Rule BMPs and the Dairy Buy-Out programs in meeting SWIM off-site phosphorus discharge standards in addition to determining their effectiveness in reducing loads to the lake. The data also serve as input to mathematical models to predict the time necessary for relic dairies to achieve the SWIM 1.2 mg/l phosphorus discharge target.

Works of the District, Rule 40E-61

The SFWMD, Works of the District, Rule 40E-61 became effective in 1989. The objective of the Rule is to identify, permit, monitor for compliance, and enforce for noncompliance on all nondairy land uses in the Lake Okeechobee basin. The Works of the District permit requires that all users within the defined boundaries of the basin meet average annual phosphorus discharge concentration standards regardless of the manner in which their water enters the system.

The Regulation Department of the SFWMD is responsible for the administration, regulation, and enforcement of the rule with support from a separate line management department (Water Resources and Evaluation) providing water quality monitoring. The data are used by the Regulation Department to verify compliance or noncompliance with the rule. A third line management department (Research) utilizes the data collected through the Dairy Rule and the Works of the District monitoring programs along with lake inflow data to determine the effectiveness of the combined programs in achieving the Lake Okeechobee SWIM plan phosphorus reduction goals.

Keys to Success

The key elements of these three programs involve the commitment, coordination, and communication of resources from various disciplines (engineers, scientists, planners, and lawyers) both internal and external to the SFWMD. In addition, the key to the success of any performance- or technology-based regulatory program is (1) a firm foundation in the legal process which empowers the regulatory agency to effectively carry out the designed mission and (2) a basis of review which, in this case, provides for the development of on-farm nutrient management strategies designed to balance nutrient imports and exports to improve runoff water quality. Lastly, regulatory agencies must have the respect of the regulated community. This can be accomplished primarily through frequent contact and communications, through public workshops, frequent dissemination of written information, and one-on-one meetings with landowners.

Seven line management departments (Planning, Water Resources and Evaluation, Research, Regulation, Office of Council, Land Management and Construction Management) were involved in implementing various facets of these programs. Commitment, communication, and coordination between and among them is also essential. The biggest problems in the program implementation occurred in those

cases where the communication and coordination links were inadequate.

Measures of Success

The Dairy Rule and the Works of the District programs combine technology based regulation for all regional dairy operations along with performance based regulation for compliance with nonpoint source phosphorus discharge standards on nondairy land uses to implement regional resource protection strategies. The success of the Dairy Rule is measured by the degree of phosphorus reduction in surface discharges from the farm. The ultimate measure of success will be the achievement of the 1.2 mg/l total phosphorus discharge target required by SWIM. The success of the Works of the District is measured quantitatively through documentation of permits issued, amount of surface area permitted, the number of sites in compliance with water quality standards, and the implementation of effective corrective action plans on noncomplying parcels.

To date, all 30 dairies participating in the Dairy Rule program have completed construction of the required BMPs. Total phosphorus concentrations have decreased by 50 percent at 75 percent of the 30 active dairy farms. Currently 15 of the dairies are meeting the 1.2 mg/l SWIM phosphorus concentration target based on 1 to 3 years of monitoring (Gunsalus et al., 1992).

Eighteen dairies participated in the Dairy Buy-out program. To date, total phosphorus concentrations have significantly improved at half of the buy-out sites although total phosphorus concentrations remain unacceptably high, greater than the 0.35 mg/l SWIM phosphorus discharge target (Gunsalus et al., 1992).

The Works of the District permitting of nondairy land uses is essentially complete. To date, 666 applications have been permitted throughout these basins covering approximately 3,298 square kilometers (1,273 square miles). Of these, 400 sites (186 permits) have been monitored for compliance. Seventeen farms have been identified as noncomplying parcels and have developed formal management strategies to come into compliance with phosphorus discharge standards.

The implementation of these three resource management strategies within the target basins has resulted in a 20 percent reduction in phosphorus loadings to the lake (Gunsalus et al., 1992). The ultimate goal is a 40 percent reduction in phosphorus loads to Lake Okeechobee.

Summary and Conclusions

Numerous state and federal agencies have participated in this environmental pro-tection effort for Lake Okeechobee. Within the SFWMD individuals from multiple scientific, planning, legal, and regulatory backgrounds, across many organizational lines, have been involved in this effort.

The Dairy Rule and the Works of the District programs appear to be effective in reducing phosphorus loads to the lake. It is still uncertain whether or not these programs will achieve a 40 percent reduction in the average annual phosphorus load to the lake. The programs have resulted in BMP implementation or voluntary closure of all dairy sources in the basin and implementation of corrective actions for phosphorus control on nondairy land uses found to be out of compliance.

Phosphorus dynamics research, current modeling efforts, and water quality monitoring continue with the purpose of evaluation of BMP effectiveness and development of new BMP alternatives.

These three programs have created a greater awareness among landowners and operators of the need for pollution control and help in the design and implementation of nutrient management strategies to improve the quality of nonpoint source runoff from individual farms. The SFWMD remains committed to these programs as the backbone of the agency strategy to preserve and protect the water quality in Lake Okeechobee.

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Using Field-Scale Simulation Models for Watershed Planning and/or Evaluation

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In this *decade of the environment*, agriculture is being called upon to quantify its effects on the quality of water. In that the environmental system is quite complex and demonstrates a remarkable capacity for buffering change, the effects are somewhat masked. Even though it takes a long time (several years) to detect degradation, it takes at least as long to detect remediation effects.

There are at least two types of data to be utilized when analyzing effects on water quality: monitored and simulated. While monitored data are directly measured, simulated data are predicted through the application of a computer physical process simulation model. There are numerous advantages and disadvantages to both types of data. The lessening of resource investment (time, money, and equipment) is the major advantage to modeling, but the absolute accuracy of simulated data is always questionable. Even though it is quite common to debate which is better, monitored or simulated data, this discussion recognizes two important points:

1. All models are built from monitored data.
2. Models work best when used in conjunction with monitored data.

There are at least three scales of nonpoint source (NPS) models:

1. Watershed or basin scale models cover large geographic areas at an abbreviated level of detail and subdivide smaller areas into homogeneous cells or sub-basins.
2. Ground-water models concentrate on the saturated zone with little interaction with the soil surface.
3. Field-scale models focus on smaller, homogeneous areas such as one field, in great detail.

Both watershed and ground-water models focus on pollutant concentrations (parts per million (ppm) or milligram per liter) within a waterbody, while field-scale models generally concentrate on loadings (grams per hectare or milligrams per liter per day) leaving the edge of the field or the bottom of the root zone.

Most water quality problems are recognized off-site from the original source of the pollutant. For example, if there is a siltation problem in a lake, the sediment actually comes from somewhere upstream in the watershed. We know that most land erodes, but the rates vary significantly. Is our problem from one single field, a construction site, or is it the aggregate of a little from numerous sources? Is one storm per year causing the problem, or is the sediment problem the combination of many storms? Watershed-level (basin-scale) models can assist us in ranking and targeting these type of questions and in estimating the cumulative sensitivity of the watershed to alternative solutions.

Field-scale models provide greater detail concerning the management practices and their effects on changes in loadings from the edge of the field and bottom of the root zone. They also naturally fit the perspective of most field level professionals

such as District Conservationists with the Soil Conservation Service (SCS), County Extension Agents with the Cooperative Extension Service (CES), and the main client, the farmer/producer. In much the same way that we could use monitored and simulated data in combination, so we can use the outputs from both field- and basin-scale models to complement each other in our effort to link land practices with water quality. In summary, this paper is limited to applying field-scale simulation models to watershed planning and evaluation of effects on the loading of waterbodies with NPS pollutants such as sediment, nitrogen, phosphorus, and pesticides.

Background

Simple models have been around for a long time, but the use of complex system models is a relatively recent endeavor mainly due to the availability of computers. A typical 30-year simulation or run of a field-scale model takes less than 2 minutes on a 486 class personal computer, but the same data processing would take an expert the better part of a lifetime using hand calculations.

The four models included in this paper encompass a large amount of work from numerous scientific disciplines including: agronomy, soils, agricultural mechanization, hydrology, geology, erosion/sedimentation, plant physiology, weed science, chemistry, biology, mathematics, economics, and general agriculture. The development of such systems models takes years of collecting, organizing, programming, validating, and refining to produce a usable tool. In truth, that usable tool is only then a rough draft which will need additional years of *trial and error* use to become a polished, reliable tool. Quite often when we assemble all that we know about a specific system we find that there are holes in our understanding. The weakness is not in the model but rather in our knowledge of the systems. Three of the four models to be discussed were developed by the U.S. Department of Agriculture - Agricultural Research Service (USDA-ARS) and the fourth by University researchers. The development period for each has stretched over 10 to 15 years, and the models are all still being supported and refined even though they are being used in various parts of the world. The four models are the Chemical Movement through Layered Soils (CMLS), the Erosion-Productivity Impact Calculator (EPIC), the Ground water Loading Effects of Agricultural Management Systems (GLEAMS), and the Nitrogen Leaching and Economic Analysis Package (NLEAP). Table 1 contains a comparative matrix of the basic water quality capabilities for each model.

Simulation models are systems tools. Most use a combination of physical and empirical relationships to track a specific resource to a complete mass balance. For example, nitrogen enters the system in various forms or pools (fertilizer, manure, through legumes, irrigation water, etc.), leaves the system (in harvest, runs off of fields, volatilizes, percolates, etc.), or remains in the system even if the form or location changes (denitrification, mineralization, plant uptake, residual in the soil, erosion and deposition, etc.). In short, all nitrogen is accounted. If we have a nitrogen concentration problem in a lake and we reduce the amount of nitrogen in runoff by incorporating our fertilizer rather than broadcasting it on the surface, where did the nitrogen reduction occur? If one pool was decreased, which other pool was increased? Were there larger crop yields, more carryover to subsequent years, or larger amounts of nitrogen leaching out the bottom of the root zone headed for the ground water? Did we

Table 1. Basic capabilities of four field-scale water quality models

	Simulated Crop Yields	Base (subsurface) Surface	Flow	Root Zone
CMLS				X
EPIC	X	X	X	X
GLEAMS		X		X
NLEAP		X		X
	Single (storm)	Daily	Annual	Continuous
CMLS	X	X	X	X
EPIC	X	X	X	X
GLEAMS	X	X	X	X
NLEAP	X	X	X	
	Pesticides	Nitrogen	Phosphorus	Buffer strips
CMLS	X			
EPIC	X	X	X	
GLEAMS	X	X	X	X
NLEAP		X		

mitigate one problem and create another? All environmental quality work must address the issues in a system fashion. Saying that the nitrates in the lake were reduced is *not* enough.

There are many field-scale simulation models available; we have a choice of which to use. Most models are *good,* as long as we are interested in the same output and assumptions as the developers. No one model is the best tool for all water quality questions; although, some are better than others. In addition, some models are more detailed/robust/sensitive in certain areas than are others. The right model is the one that does the best job for you (Griggs, 1990).

SCS has identified nine steps in the watershed planning process (USDA-SCS, 1991) and has elaborated on their application to water quality concerns (USDA-SCS, 1992):

1. Identify the problem.
2. Determine the objectives.
3. Inventory the resource.
4. Analyze the resource data.
5. Formulate alternative solutions.
6. Evaluate alternative solutions.
7. Client determines a course of action.
8. Client implements the plan.
9. Evaluation of the results of the plan.

Field-scale simulation models could and quite often should be directly or indirectly part of all of these steps with the exception of steps numbered seven and eight. Rather than a list of nine sequential steps, in reality this planning process is a continuum. For example, after analyzing the resource data, the problem can be further identified, or after the evaluation of the results, other alternatives can be formulated and evaluated.

Evaluation (assessment) is an important mid-stream step as well as a final grade for water quality project efforts. As input data become more detailed and more reliable, original objectives and methods should be re-evaluated and refined. Project goals may be unchanged, but the steps to reach the goals might need some refining. Changing our direction due to additional understanding is not a crime, but continuing on in the wrong (even the second best) direction due to pride or worse yet because we failed to take time to evaluate mid-stream is! On the same note, field workers must have access to and be included in the evaluation (mid-stream and final) process. Communication becomes even more critical because self-evaluation can be an excellent teaching tool if, and only if, the results are shared with the field staff.

Example Planning/Evaluation Scenarios

The following is a generic example of how field-scale models could be a part of the nine-step watershed water quality planning process.

First, *identify* the water quality *problem(s)* or challenge(s) and then prioritize them (e.g., Atrazine concentration (parts/million—ppm) in ground water, preventing sediment deposition (metric tonnes) in a planned reservoir, and eutrophication in a nitrogen limited stream (ppm)).

Second, *determine* specific and measurable *objectives* directly related to the identified problem(s) and/or challenge(s) (e.g., reduce the amount (gram/hectare) of Atrazine leaving the bottom of the rootzone by 30 percent, reduce the amount of sediment (tonnes/hectare) leaving the edge of the fields by 50 percent, and reduce total nitrogen leaving the edge of the fields (kilogram/hectare) by 25 percent). These example percentages are a first draft and should be back-calculated from the problem(s). Note that the objectives include specific points of interest for measurements and are within the realms of most field-scale models (edge-of-field and bottom-of-rootzone).

Third, *inventory* the *resources.* Which field-scale models address the desired water quality indicators? A water quality indicator is defined as a measurable parameter (e.g., daily mass of Atrazine leaving the edge of the field in runoff water). Determine the inputs (required and optional) needed by the selected model(s). The sensitivities of different models to specific input parameters are often times very different (Table 2 and Table 3).

The fourth step of the watershed water quality planning procedure is to *analyze* the *resource data.* That would include making baseline simulations (before project). Check the hydrology of the simulation. Is it reasonable? Determine the sensitivity of the system being simulated (e.g., How much do I have to reduce the nitrogen input (kilogram/hectare) or change the management practices by to see

Table 2. Water quality indicators

Pesticides	CMLS	EPIC	GLEAMS	NLEAP
in runoff (g/ha)		X	X	
in runoff (ppm)		X	X	
in subsurface flow (g/ha)		X		
in subsurface flow (ppm)		X		
attached to eroded sediment (g/ha)		X	X	
attached to eroded sediment (ppm)		X	X	
in percolate (g/ha)	X	X	X	
in percolate (ppm)		X	X	

Table 3. GLEAMS model pesticide mass balance worksheet

Description of Pool	Parameters Input	Parameters Output	Units
Start of Simulation:			
residue on foliage (concentration)	FOLRES		mg/g
residue in soil layers (concentration)	RESDUE		mg/g
Additions:			
applied	APRATE		kg/ha
Losses:			
in runoff (mass)		601-610	g/ha
in lost sediment (mass)		651-660	g/ha
leached below the root zone (mass)		701-710	g/ha
in runoff (mass)		611-620	mg/l
End of Simulation:			
on foliage at the end of a day	PFOL		kg/ha
in the soil at the end of a day	PSOL		kg/ha
Other:			
in the soil (mass by layer)		801-810	mg/g
in the soil (concentration by layer)		811-820	mg/g
in loss sediment (concentration)		611-670	mg/g
leached below the root zone (conc.)		711-720	mg/l
total losses (mass)		751-760	g/ha
in H_2O (concentration by soil layer)		821-830	mg/l
in soil (concentration by soil layer)		831-840	mg/g

a 25 percent reduction in nitrogen surface losses?). If historical data are available, past/present/future trends can be simulated at this time. Additional resource needs may be determined.

Fifth, from the preceding step and using the knowledge and experience of the local field staff, *alternative Resource Management Systems (RMS)* solutions should be *formulated.* These might include:

- Different chemical formulations of nitrogen and phosphorus.
- Stickers, emulsifiers, extenders, and inhibitors for nitrogen and phosphorus.
- Reduced application rates for nitrogen and phosphorus without reducing crop yields.
- Different nitrogen and phosphorus application methods: over the top, incorporated, injected, or banding.
- Alternative timing of nitrogen and phosphorus applications, split applications.
- Crop rotations.
- Irrigation practices: center pivot, Low Energy Precision Application (LEPA), sprinkler, furrow, drip, chemigation, or fertigation.
- Tillage practices: fall plow, spring plow, no-till, reduced till, ridge till, type, depth, timing, and number of passes.
- Residue: high, medium, or low.
- Structures: ponds, terraces, wetlands, grassed waterways, filter/buffer strips, and riparian zones.

Sixth, *evaluate* the *effects of alternative* individual and systems of *practices* on the entire hydrologic system. Remember to compare effects on all of the following: water, sediment, nitrogen, phosphorus, and pesticide losses from the system. Note, changing the surface losses will generally affect the bottom of the rootzone losses as well. The models and the environment maintain a mass balance (conservation of matter) for all of the potential contaminants. "After" RMS simulations are compared to the "before" simulations to determine the best RMS considering all of the goals of step two. At this point, the goals may need to be refined and/or the alternative RMS solutions might need further development in order to meet the goals of step two.

Seventh, the *client* (usually the producer) *determines a course of action.*

Eighth, the *client implements* the chosen course of action.

The ninth and final step is to *evaluate the results* that the RMS had on the problems/challenges of step one. This is a refinement of the chosen course of action after simulations of step number six using monitoring data, actual historical climate data, actual land treatment tracking (percentage adoption), and any other additional developments.

Needs

Among these four models, there are issues and/or practices that the models

cannot address, are not validated for addressing, or the documentation is not clear on exactly how to address. Many of these practices are already being prescribed as part of the RMSs for maintaining and/or improving water quality, but the models are lagging behind in technology. Following is a list of some of the model weaknesses concerning water quality issues:

- *Animal grazing:* Handling both animal grazing and water quality indicators.
- *Banding of nutrients and pesticides:* None are spatially distributed within a field area. Pesticide and nutrient applications are considered to be homogeneous for the entire area.
- *Gully erosion:* Another spatially distributed parameter similar to banding. The models handle sheet and rill erosion as it is homogeneously distributed over the field. Since gully erosion is not homogeneously distributed most of the models do not address it.
- *Buffer strips/riparian zones/grassed waterways:* GLEAMS is the only one of these that does simulate buffer strips, but does not simulate crop yields (one of the most critical nutrient cycling aspects).
- *Chemical interactions (pesticides):* None address interactions between pesticides even though we know that chemically there are interactions. Currently, one simulation with two pesticides is in reality just two separate simulations with one pesticide each.
- *Flood irrigated (paddy) rice:* None completely handle saturated conditions. Many of the chemical processes take different metabolic pathways under anaerobic than under aerobic conditions.
- *High water tables:* Another phenomenon similar to the anaerobic conditions described in the flood irrigated rice deficiency described above.
- *Furrow/surge irrigation:* Water is not distributed evenly along the furrow in the real world and water is the principle, if not the only, carrier of chemicals in these models.
- *Trickle irrigation:* Another distributed activity like the banding and furrow irrigation questions.
- *Maximum contaminant level/health advisory level warnings (habitat suitability):* The models give output numbers but do not address the differences in risk factors for very different compounds (e.g., one gram of nitrate is not as much of a risk factor as one gram of Atrazine).
- *Minor crops (e.g., vegetables):* The crop growth subroutines do not generally have growth parameters for cucumbers and other minor crops. Vegetables are sometimes examples of worse case scenarios since three and four crops can be grown on the same field in one year.
- *Mixed plant populations:* Rangeland, pasture land, and weed/crop scenarios are very different from a monocrop situation.
- *Rangeland:* In addition to the mixed population and grazing questions, rangelands ecosystems are very different than row cropped land. Even if the models will work well in rangeland situation, very little validation work has been documented.
- *Integrated crop management (ICM) or integrated pest management (IPM):* Herbicide applications are generally made in response to weed pressures which vary from year to year and likewise insecticides are applied only when a predetermined threshold is exceeded. The models must be able to interactively make adjustments throughout the simulations rather than only repeat uniform management practices.
- *Nitrogen inhibitors:* This is an additive which reduces the rate in which nitrogen is transformed.
- *Pesticide additives (emulsifiers, stickers, and wetting agents):* Like the nitrogen inhibitor example above, these additives alter the chemical and physical properties of pesticides. The degradation and attachment to foliage is altered significantly and can have a major effect on the fate and transport of pesticides.
- *Stochastic input/output variables:* Variability is more common in nature than are averages (e.g., the average annual temperature of Honolulu, Hawaii, and Bismarck, North Dakota, are similar but the ranges are significantly different). Average annual amount of Atrazine in the

water may be well below the 3 parts per billion U.S. Environmental Protection Agency (EPA) drinking water standard, but if this standard is exceeded even part of one day out of the year some life forms may be in danger. This variability in soils, application rates, and plant densities in addition to climate is important in environmental risk determinations.

- *Sub-surface drainage (tile drainage):* Vegetable, fruit, and some row crops use tile drains to reduce anaerobic conditions. This can accelerate the translocation of agricultural chemicals to surface waterbodies.
- *Sub-surface flow (base flow):* Depending on soil and geological conditions, significant portions of stream base flow return to streams under the surface and not only as overland runoff.
- *Volatilization:* Some forms of nitrogen and some pesticides are mainly lost through this form of transformation. Most of the models ignore some portion of this.
- *Wetlands:* Another of the saturated or anaerobic situations. Several of the EPA surface water quality models address this phenomenon in great detail.

Some Recommendations for Proper Field-Scale Model Use

Models are very complicated collections of science which were assembled in an attempt to simplify the work of potential users. Since proper use is still not too simple, there are some basic steps to follow. First, the user must be able to choose the best model(s) for each water quality situation or collection of situations. Then, in order to use the model(s) correctly, the user must invest a lot of time to understand the theory, become accustomed to the software, learn where and how to obtain the needed input data, be able to troubleshoot the simulations, and become familiar with the output. It is much easier to misuse models and to approach the science as a *blackbox* (accept the output as truth). Models are not expert systems or artificial intelligence tools. They require expert human planning, interpretation, and analysis.

It is important that national program leaders give sufficient guidance and technical support to individuals who are given assignments to prepare modeled output data in annual progress reports. Using a simulation model two or three times per year is not efficient. If used correctly the user must be very familiar with the tool; this means that literally hundreds of hours must be experienced on a regular basis. For example, if a progress report states, *"Our modeling efforts predict little to no reduction in nitrogen loadings in the lake down-stream even after increasing residue left on the surface,"* the reader still needs to know (1) how staff are using the output data and (2) what difference this self-evaluation process is having on the project activities and its expectations for impact on water quality. Hopefully, the example above would have the following statement added to it *". . .; therefore, we are now exploring alternatives such as split spring nitrogen applications and no-till."*

Teams, not individuals, should use and support modeling efforts. Soil science, hydrology, economics, entomology, plant physiology, chemistry, biology, weed science, erosion, sedimentation, entomology, geology, and tillage are all major components of these models.

Models should be used as one of a battery of tools to be used within a plan of analysis.

Users should take special pains to thoroughly document model use. For example, EPIC has choices for calculating erosion/sediment yield—the Universal Soil Loss Equation (USLE) predicts erosion; while the Modified USLE (MUSLE) and Onstad-Foster (OF) methods calculate sediment yield at the edge of the field. Depending on which choice the model user makes, the results are quite different in quantity and meaning.

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Consequences of Urbanization on Aquatic Systems—Measured Effects, Degradation Thresholds, and Corrective Strategies

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Urbanization imposes a variety of watershed changes that profoundly affect runoff processes and the downstream surface-water drainage system. These changes include not only the most obvious manifestation of urban development, namely impervious surfaces that cover the land, but also the associated vegetation clearing, soil compaction, water-conveyance modifications, riparian-corridor alterations, human intrusion, and import of chemical contaminants that invariably accompany such development. These pervasive, landscape-level changes commonly affect virtually all areas of an urban watershed.

Downstream channels reflect these watershed changes in a variety of ways. Increases in peak flows have been best documented, with the discharge of floods of a given recurrence interval typically increasing by factors of about 2 to 5. Recent, more sophisticated monitoring and numerical modeling of urbanizing drainage basins show that the duration of any given flood discharge, summed over the time period of gage record or simulation, may increase by an order of magnitude. Such modeling also shows that the frequency of "large" flows, recognized by the discharge necessary to accomplish significant erosive work on the channel form, may increase by nearly two orders of magnitude—from once or twice per decade to several times per year (Booth, 1991).

Physical conditions in channels also change as a result of urbanization. Some of those changes are a direct consequence of development and human habitation—riparian corridors are cleared, channels are straightened, and logs are removed from channels in the name of tidiness or for firewood. Other changes result from the increase in flows delivered from the upstream basin. These flows transport more sediment as a result of increased flow durations and accomplish more channel erosion as a result of the increased frequency of large floods. Geomorphic work on the channel is increased even as the resistance of the channel to that work, typically derived from the roughness and armoring properties of bank vegetation and large woody debris, is reduced. Urban channels are therefore deeper, wider, and commonly incised; they are also more homogenous with little of the morphological variability, such as alternating pools and riffles, that characterizes channels in more undisturbed settings.

The chemical composition of urban storm water also differs, sometimes dramatically, from predevelopment conditions. Although measured data vary widely between systems, increases of up to one order of magnitude are typical for most pollutant classes, including solids, nutrients, metals, and bacteria. Construction-phase impacts can be particularly severe on stream systems and wetlands with small drainage areas.

In summary, landscape alteration affects aquatic system function, primarily

by the physical processes of reduced soil-moisture storage by compaction and paving, direct human intrusion into streams and wetlands, and import of pollutants. In recognition of these dominant processes, we have collected sets of physical, chemical, and biological data from a wide variety of lowland streams and wetlands in King County, western Washington State. We seek both a threshold of significant aquatic system degradation, which appears from our data to occur at a rather well-defined level of urbanization, and insight into the processes by which that degradation occurs. Only with such insight are subsequent efforts at mitigation or protection likely to be successful.

Choice of Parameters and Methods of Data Collection

We have chosen to consider data from both streams and wetlands because these two classes of aquatic features are intimately interconnected in the watersheds of western Washington. The *structure* of these features is evaluated through measurement of physical parameters, such as bankfull width and depth for channels, or fluctuations in water level and water chemistry for wetlands. The *function* of these aquatic systems is measured by biological utilization, which is judged to integrate the suite of urban induced effects and to provide the best aggregate measures of "quality" or "degradation." We have evaluated biological parameters quantitatively by species and population counts, and more qualitatively by rapid field assessment of habitat quality.

Urbanization is similarly diverse in characterization. Several parameters have been used by past workers (e.g., percentage of area urbanized, percentage of area served by storm sewers); all are strongly cross-correlated, and so to some extent the choice is a matter of personal preference. We have elected to cast all data in terms of the percentage impervious area in a watershed, using typical impervious-area ratios for individual land uses; this parameter can be unequivocally measured and is particularly well correlated with the runoff processes that we judge are most significant. We also have independently measured conditions of the riparian corridor because these areas are directly connected to aquatic systems and because many jurisdictions are actively regulating these zones independent of broader, watershed-level controls.

Correlations Between Urbanization and Aquatic System Function

In aggregate, the physical changes imposed by urban development on the landscape result in a decline in function of aquatic systems. This fact is evident to any resident of such a watershed; similarly intuitive is the observation that degradation increases as development progresses. However, it is much more difficult to quantify decline in function and identify its relationship with upstream urbanization.

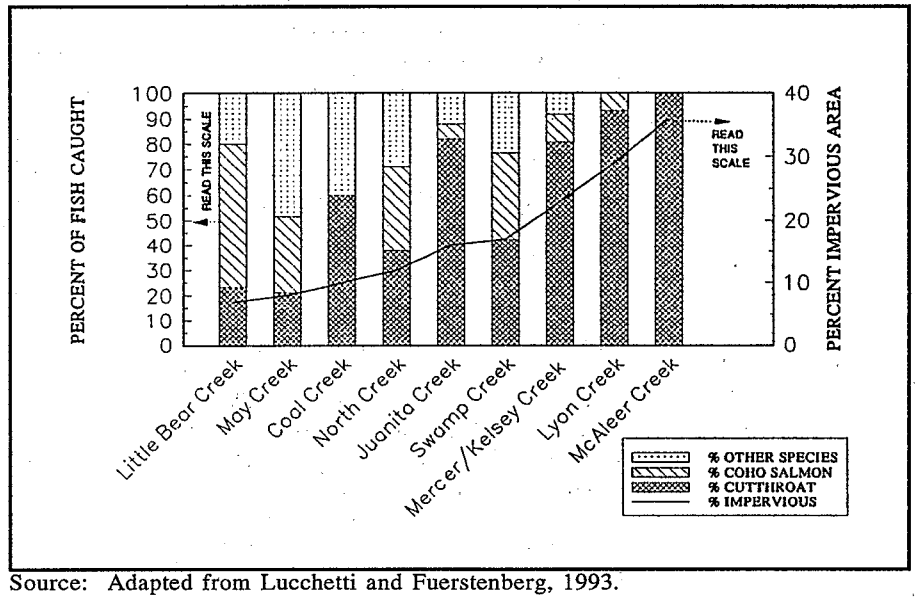
We have sought such a relationship by use of both new and existing data, relying heavily on biological indicators of stream and wetland function. Fish use in streams has been investigated directly by Lucchetti and Fuerstenberg (1993), who considered the differences in relative abundance between two species of salmon, cutthroat trout (*Onchorynchus clarki*) and coho salmon (*O. kisutch*), that have significantly different life cycles and habitat requirements. Cutthroat trout are tolerant of small-sized and relatively homogenous habitat; coho salmon, in contrast, require a varied physical environment that includes large pools and a stable substrate. Figure 1 shows the relationship between populations and watershed impervious-area percentages for eight similarly sized drainage basins in western Washington (ranging in drainage area from 10 to 30 km^2). The data show little in the way of a discrete "threshold" but indicate that population changes may be measurable at rather low levels of urban development and become quite significant much beyond 10-15 percent.

Similarly, the relationship between fish habitat and urban development was evaluated by rapid field assessment along 140 km of stream channel in two drainage basins (Soos and Hylebos Creeks) in King County. Habitat was classified as excellent, fair, or poor on the basis of pool:riffle ratio, channel roughness and diversity, and observed fish use. The total contributing area and impervious-area percentage of the watershed above each channel reach was measured, with total areas ranging from 2 to 110 km^2 and impervious areas ranging

from 2 to 50 percent. The results are graphed in Figure 2; marked degradation occurs at about 8-10 percent impervious area with almost no exceptions on either side of that value.

Data collected from 19 wetlands throughout King County (Reinelt and Horner, 1991; Richter et al., 1991) suggest a similar pattern. Wetland function was characterized by measurement of hydrology, water quality, soils, plants, and animals in these wetlands from 1988 to 1990. Water-level fluctuation (WLF) was chosen as the primary measure of hydrology because it integrates numerous factors governing wetland hydrology, including wetland-to-watershed area ratios, level of watershed development, wetland morphometry, outlet conditions, and soils. Mean WLF was used in this analysis because it is less influenced by evaporation and summer drying. Water quality analyses examined 21 variables, including nutrients, metals, and bacteria, with a majority of samples collected during the wet (November-February) and dry (July-September) seasons; conductivity, total suspended solids (TSS), and fecal coliforms (FC) showed the greatest systematic variation (Reinelt and Horner, 1991). The diversity and abundance of amphibians, collected in pitfall traps and supplemented by egg-mass observations, were used to characterize animal use in wetlands (Richter et al., 1991).

The five variables noted above (WLF, conductivity, TSS, FC, and amphibian species) were used to compare wetland function with percentage impervious area in the wetland watersheds. Each variable was scored from 0 to 100, where 0 represented the least degraded value in the entire data set and 100 the most degraded value. Other scores were assigned proportionally between these two extremes. A "water quality" score was calculated as the mean of the three water quality variables; it was then averaged with WLF and amphibian scores (Figure 3). These data support the intuitive knowledge that increased levels of urban development yield increased degradation, although this particular data set is deficient in impervious-area percentages between 4 and 14 percent. With one exception (JC28, with only moderate water quality degradation and almost no WLF as a result of exceptionally permeable watershed soils and a very stable regional ground-water table), all wetlands with impervious-area



Source: Adapted from Lucchetti and Fuerstenberg, 1993.

Figure 1. Relative fish use, King County streams.

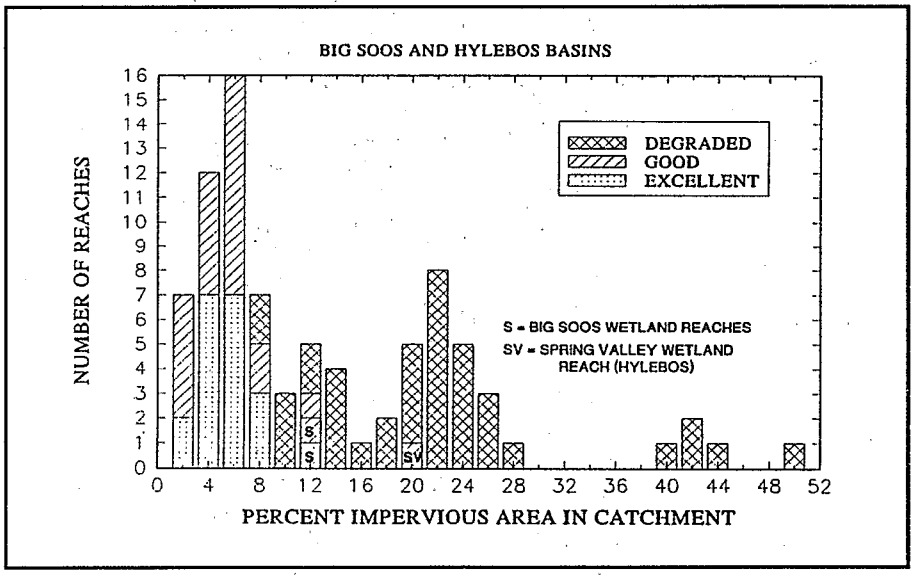


Figure 2. Quality of observed fish habitat.

percentages above 14 percent had scores greater than 50 percent, whereas those below 4 percent had scores below 40.

Causal Relationships Between Development and Function

Although the above examples clearly display a linkage between aquatic system function and urban development, they do not offer much insight into the causal relationship(s) between the likely vectors of urban impacts (e.g., flow, water quality, physical intrusion) and the resulting changes in function. To achieve such insight, we must seek data that successfully isolate the effects of one urban development parameter from all others. To date, our information is largely restricted to measures of flow quantity, channel size, and condition of the riparian corridor; but additional investigation of water chemistry changes is probably warranted as well.

The effects of changing the riparian corridor can be evaluated by measurement of channel characteristics along a stream reach with varying adjacent land use. Along one such western Washington stream (Leach Creek, with a drainage area of about 9 km^2), bankfull channel widths and adjacent bank conditions were measured at 20-m intervals along 2 km of channel (Figure 4). An average 0.6 m of channel widening has occurred wherever the native bank vegetation had been altered or removed. This increase, about 17 percent, is trivial in comparison to the potential magnitude of catastrophic channel incision but a substantial fraction of the total "equilibrium" channel widening normally associated with urban-induced flow increases (Hammer, 1972; Booth, 1990). More generally, corridor condition and habitat quality were correlated in two other basins (Figure 5); note that good habitat quality is not guaranteed by corridor conditions, but an *absence* of significant riparian vegetation virtually assures degraded habitat.

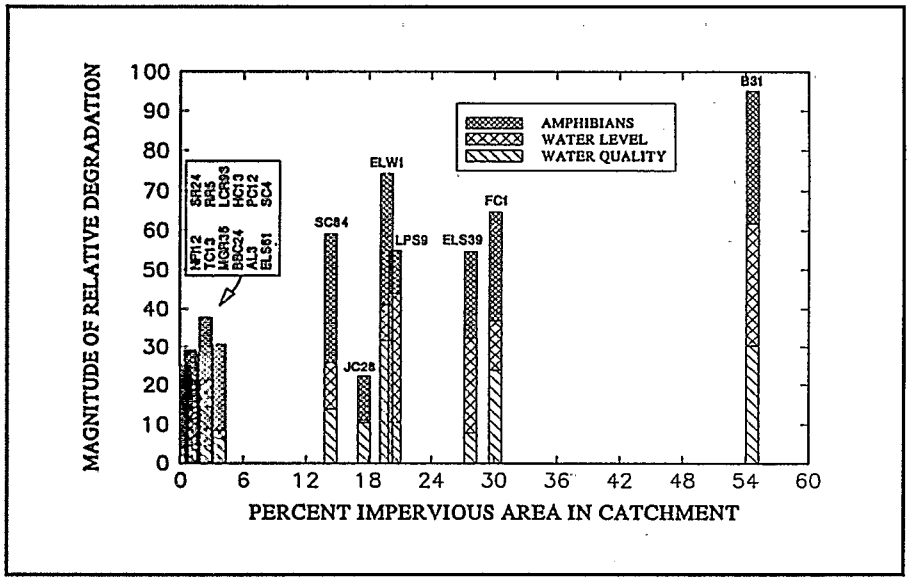


Figure 3. Relative wetland degradation.

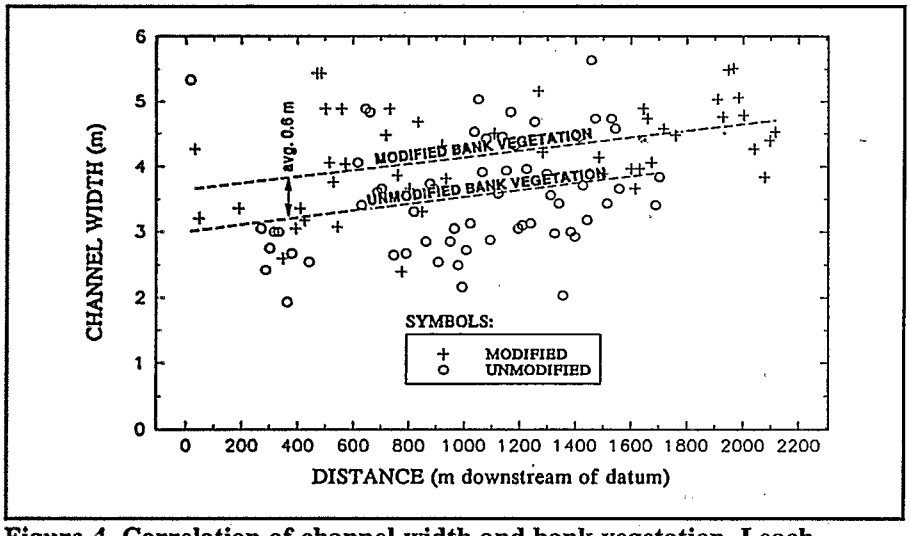


Figure 4. Correlation of channel width and bank vegetation, Leach Creek, Washington.

Changes in flood discharge from urbanization are likely to affect aquatic systems most directly by an increase in streambank instability and channel erosion. We discriminate between *stable* channels, with little or no erosion of their bed and banks, and *unstable* channels that display long continuous reaches with bare and destabilized banks indicative of severe downcutting and widening. To characterize the increase in flows imposed by urbanization, we have used a continuous hydrologic model (HSPF; USEPA, 1984) to

simulate the increased frequency of equaling or exceeding the discharge with a recurrence of 10 years under forested conditions ($Q_{10\text{-}for}$). This discharge was chosen as an index value of the total hydrograph because moderately large storm flows are commonly observed to affect stream-channel form and to move large streambed material (e.g., Sidle, 1988). The correlation between observed channel stability (indicated by the X's and O's of Figure 6) and frequency of $Q_{10\text{-}for}$ under current conditions (vertical scale of Figure 6) was determined for four basins having HSPF simulation of both forested and current land cover. A consistent threshold of change is seen for those basins with a present-day recurrence of 2 years or less for the discharge equal to $Q_{10\text{-}for}$ (solid horizontal line in Figure 6, using the annual flood series). This threshold of instability also can be recognized simply by measuring impervious area percentage in the upstream basin; again, a value of about 10 percent (dashed vertical line in Figure 6) seems pivotal.

These two factors, decreased corridor integrity and increased flows from the upstream basin, are typically interdependent because urban development tends to affect both. Different management strategies apply to these two areas, however, and so discriminating their respective effects on the stream system is valuable. Steedman (1988) correlated the biologic function at 209 stream sites in southern Ontario, Canada, with land use and riparian corridor (Figure 7). As with our data (Figures 2 and 5), both watershed and riparian land uses must be favorable (i.e., non-urban) for best conditions. If corridor clearing is proportional to basinwide urban land uses (the diagonal dashed line of Figure 7), stream conditions can be no better than "fair" once the basin achieves about 30 percent urban land use. At typical suburban densities, this corresponds to about 7-10 percent impervious area. Even with virtually complete retention of streamside buffers (i.e., "percentage riparian forest" equals 100 percent), impervious-area coverage much beyond this range will lead to nearly certain, measurable degradation.

Conclusions

These results suggest remarkably clear and consistent thresholds of aquatic system degradation. In this region, approximately 10 percent impervious area in a watershed typically yields demonstrable, and probably irreversible, loss of aquatic

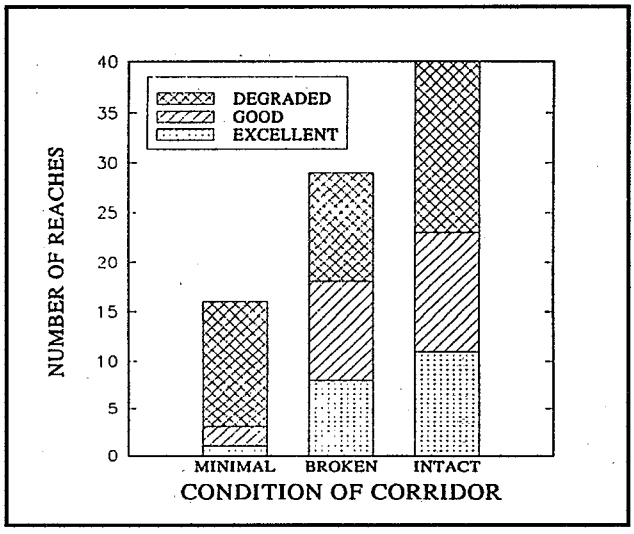


Figure 5. Quality of observed fish habitat, corridor conditions—Soos and Hylebos.

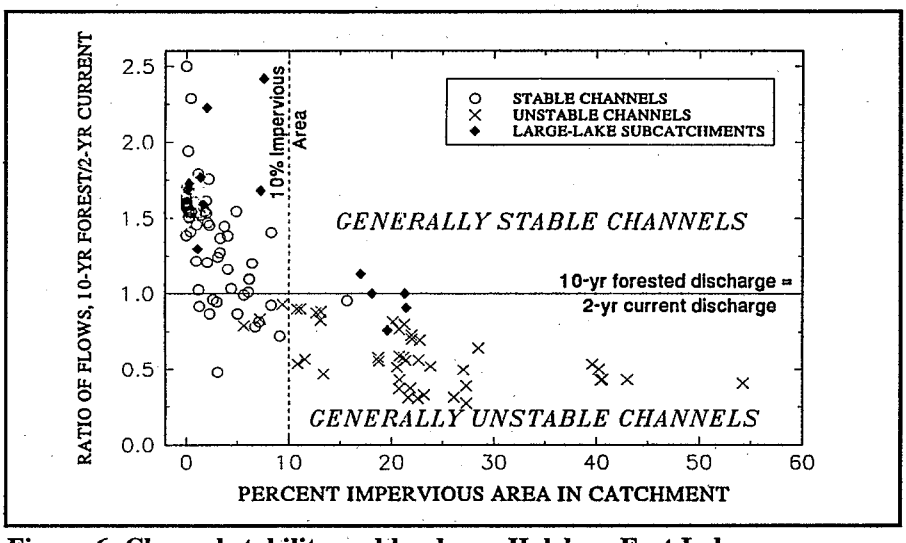
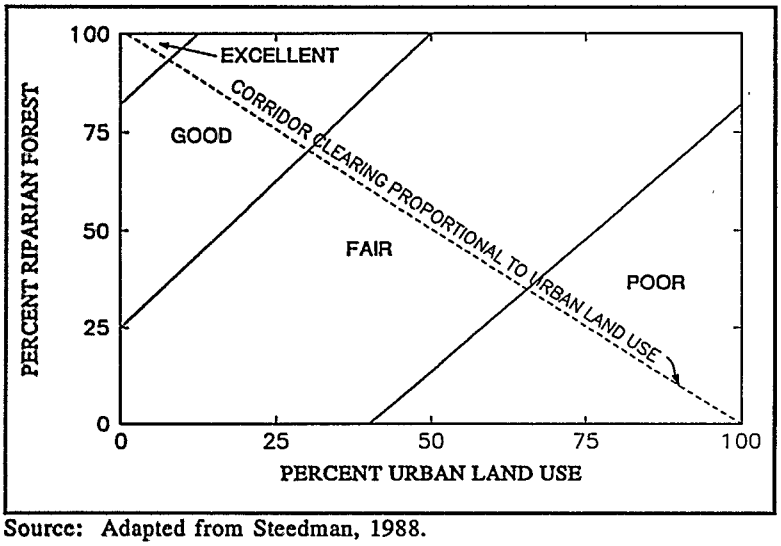


Figure 6. Channel stability and land use, Hylebos, East Lake Sammamish, Issaquah Basins.



Source: Adapted from Steedman, 1988.

Figure 7. Urban effects on biotic integrity.

system function. This loss is reflected by measured changes in channel morphology, fish and amphibian populations, vegetation succession, and water chemistry. Even lower levels of urban development cause significant degradation in sensitive waterbodies and a reduced, but less well quantified, degree of loss throughout the system as a whole. In the restricted context of western Washington aquatic systems, differences between watersheds are not apparently critical in determining this threshold; but those differences do determine the magnitude of the aquatic system response and what strategies might provide effective mitigation.

These findings suggest that successful corrective measures must not simply protect or restore the structure of individual stream or wetland elements. For example, buffers around waterbodies are necessary but must be combined with watershed-level restrictions on the rate and duration of storm water discharge; loss of instream fish habitat cannot be repaired by engineered structures alone. Yet the changes to the landscape imposed by urbanization are probably beyond our best efforts to fully correct them. Thus some downstream loss is probably inevitable without limiting the extent of development itself, a strategy that is being used with increasing frequency in this region's remaining resource-rich watersheds.

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Use of Rapid Bioassessment Protocols to Evaluate the Effects of Combined Sewer Overflows on Biological Intregrity

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There is increasing interest in the effects of combined sewer overflows (CSOs) on the biological integrity of streams and rivers and the ability to detect those effects. Instream communities act as continuous monitors of water quality; they assimilate impacts from CSOs, storm water, nonpoint sources, and other urban sources that may be missed during sporadic chemical sampling (Ohio EPA, 1987; USEPA, 1990). Characterization of the biological community provides a good measure of the cumulative instream effects. Rapid bioassessment protocols (RBPs) were developed to provide a relatively time-efficient and systematic process for detecting changes in biological condition due to chemical and physical habitat alteration (Plafkin et. al., 1989). For stream-dwelling macroinvertebrates, the U.S. Environmental Protection Agency (EPA) has established three protocols of progressively increasing detail; this study utilizes the most comprehensive version, RBP III.

This project was initiated by EPA's Office of Wetlands, Oceans, and Watersheds (OWOW) and Office of Science and Technology (OST) to evaluate the impact of CSOs on biological integrity, determine the usefulness of RBPs in detecting those effects, and compare the RBP assessment to available historical data from the targeted waterbodies. Three study areas were selected within the State of Ohio (Figure 1) based on the substantial Ohio Environmental Protection Agency (Ohio EPA) historical database of biological assessments along CSO-impacted river miles. For each study area RBP III was used. This procedure, as in RBP I and II, provides for an interpretation of biological condition in the context of habitat quality. Habitat quality is evaluated by using the RBP habitat assessment procedures.

Habitat is a critical determinant of biological potential and should be used in an integrated assessment of biological condition (Barbour and Stribling, 1991). The RBP habitat assessment includes an examination of the substrate, instream cover, channel morphology, riparian zone, and bank structure. By comparing the habitat characteristics at a study site with the characteristics at a reference site, which represents minimally impacted conditions in an ecologically similar waterbody, a determination can be made as to whether biological impairment is due to habitat degradation, excessive pollutant loads, or a combination of both.

The observed biological condition at the reference site, either the ecoregional or upstream reference, is used to develop scoring criteria for the study area. This is done by associating the biological condition with the habitat condition at the reference site. If habitat conditions at the sampling stations within the study area are degraded relative to the habitat condition at the reference site, then any detected impairment

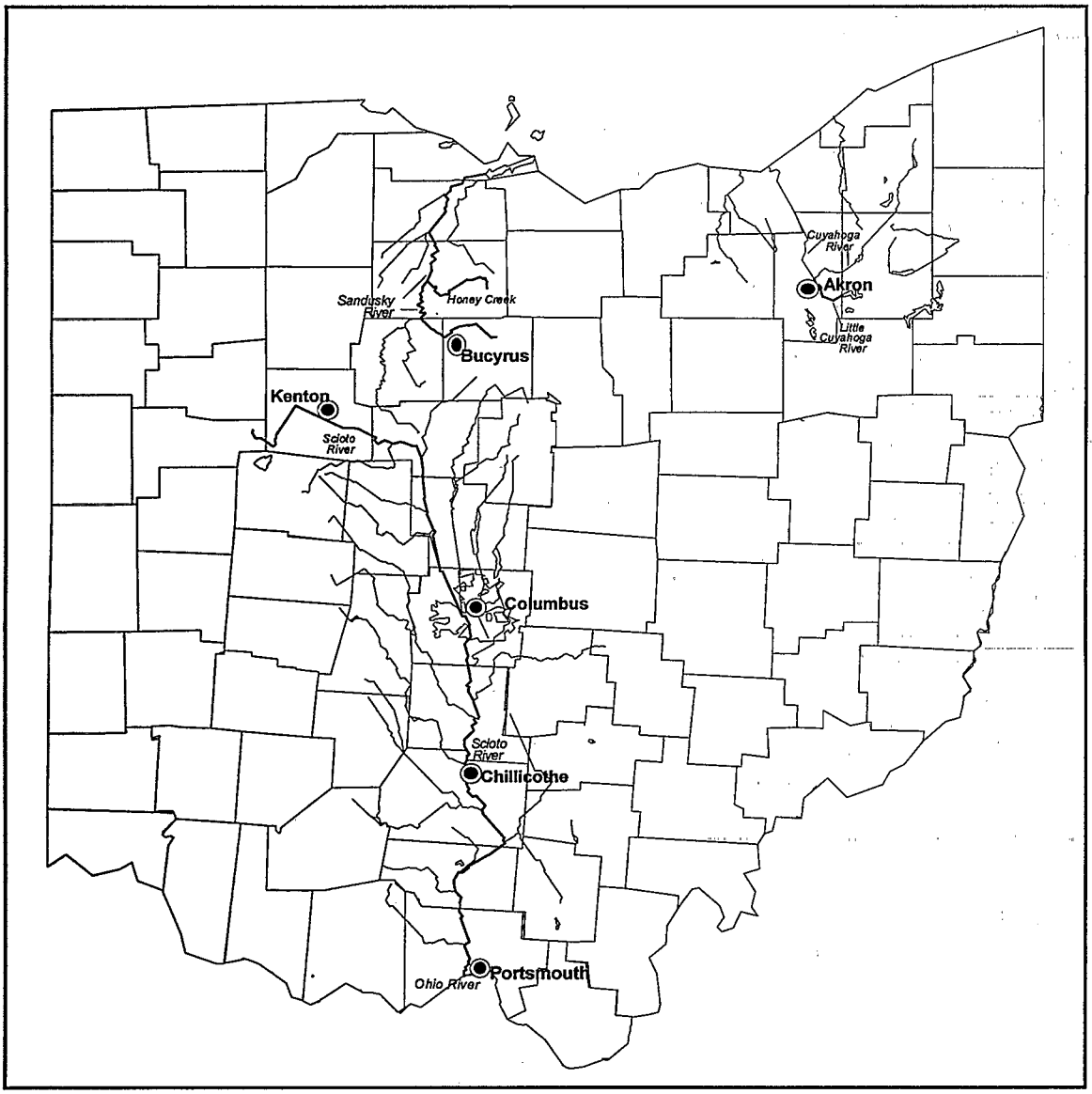

Figure 1. State of Ohio; three river systems within which the CSO study occurred: the Scioto River at Columbus, the Sandusky River at Bucyrus, and the Little Cuyahoga River at Akron.

of the biological condition at the sampling station may be attributable to either water quality impairments due to CSO pollutant loads or to habitat degradation. Only when habitat conditions at the sampling stations are comparable to habitat conditions at the reference site will impairment of the biological condition be most certainly attributable to CSO impacts. As habitat is degraded, the degree of certainty of establishing the cause of impairment of biological integrity decreases (Figure 2) because in such situations there are normally multiple stressors on the ecosystem.

The biological community analysis consists of calculating a series of "metrics," each measuring a different aspect of community structure, balance, and trophic structure. The assessment integrates the metrics and compares them to reference values. This assessment allows calculation of the biological potential at the test site if habitat and pollutant impairments were corrected. Evaluations can be made of the generic causes of impairments by examining the individual metrics (Yoder, 1991; Shackleford, 1988). Different types of organisms have distinct reactions to various types of

stresses. For example, metrics that focus on invertebrates relying on particulate matter such as leaf litter for food could be used as a screening tool for assessing the impact of toxics bound to the particulate matter or the impact of riparian vegetative degradation. The ability of biological metrics to accurately diagnose the cause or causes of biological impairment is still limited, but continues to improve as the metrics are refined.

The benthic macroinvertebrate metrics used to describe biological condition in this study are:

1. Taxa richness.
2. Hilsenhoff Biotic Index.
3. Scrapers/(Scrapers + Filter-collectors).
4. EPT/(EPT + Chironomidae), where EPT stands for Ephemeroptera, Plecoptera, and Trichoptera.
5. Percent contribution of dominant taxon.
6. EPT Index.
7. Shredders/Total organisms.
8. Hydropsychidae/Total Trichoptera.
9. Pinkham-Pearson Community Similarity Index.
10. Quantitative Similarity Index for Taxa.
11. Dominants-in-Common-5.
12. Quantitative Similarity Index for Functional Feeding Groups.

For a full description of these metrics, see Plafkin et al. (1989) and Barbour et al. (1992).

Three CSO-impacted rivers were identified by the Ohio EPA (Figure 1): the Scioto River at Columbus, the Sandusky River at Bucyrus, and the Little Cuyahoga River at Akron. Four sampling stations were located in each river:

1. Upstream of CSO influence (upstream reference).
2. Downstream, but within the zone of CSO influence.
3. Further downstream, but possibly still within the zone of CSO influence.
4. Outside of the zone of CSO influence, either further downstream or in a separate, nonaffected subwatershed (ecoregional reference).

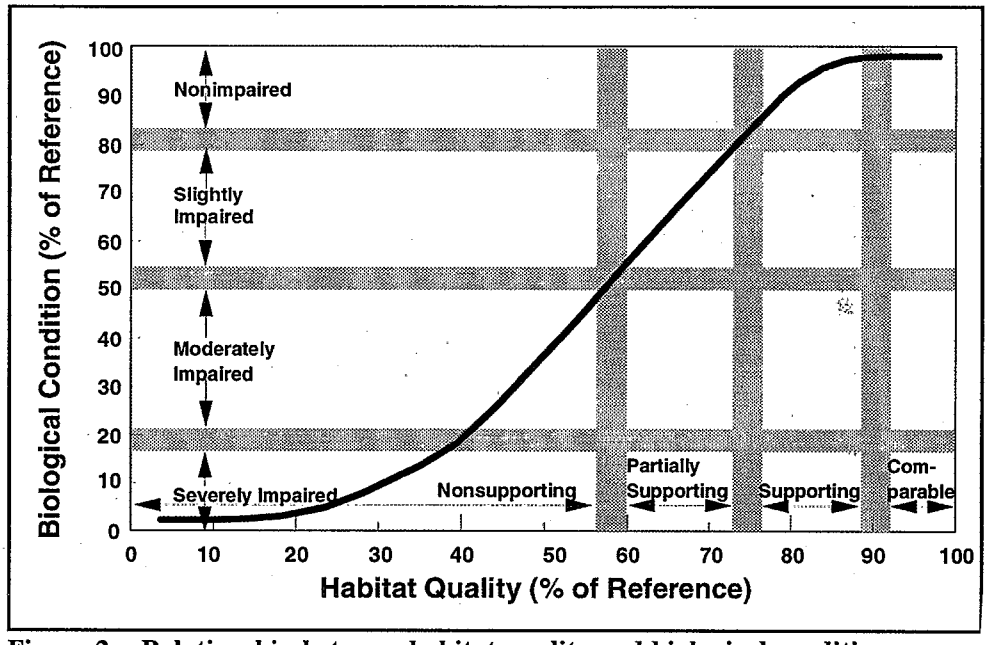

Figure 2. Relationship between habitat quality and biological condition.

Biological assessments were based on a single, composited macroinvertebrate collection from riffles at each station. The organisms were identified to the lowest possible taxonomic level, in most cases the generic level. The selected community metrics were calculated, scoring criteria assigned, and a determination made of biological condition relative to the reference condition (percent comparability).

The Scioto River is a major tributary of the southern Ohio River (Figure 1) and has a long history of degradation from upstream water withdrawals, old channel modifications, urban runoff, and the input of organic matter and nutrients from CSOs. Historical monitoring by Ohio EPA has generally rated the biological conditions in the Scioto near Columbus as "poor" or "fair." Results from the current study were consistent with historical data. Habitat conditions were judged to be sufficiently similar so that any biological differences should be due to water quality effects. The two stations within the zone of CSO influence (S2 and S3) were found to exhibit "moderate" and "slight" impairment relative to the ecoregional reference station (S4) (Figure 3). Examination of individual metrics indicated that impairment may be due to organic enrichment and an increase in

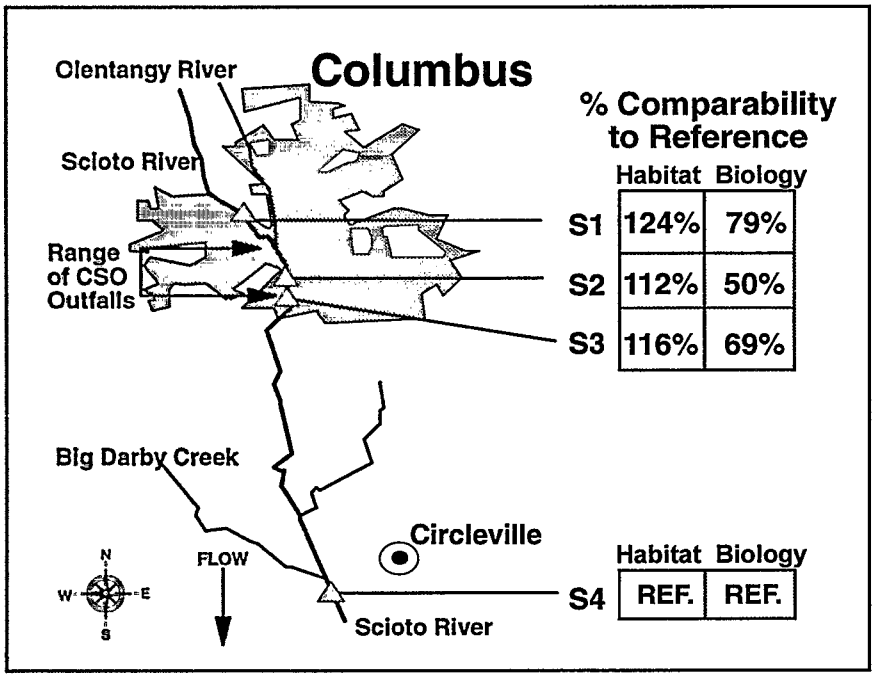

Figure 3. Scioto River at Columbus; percent comparability of sampling sites to reference condition.

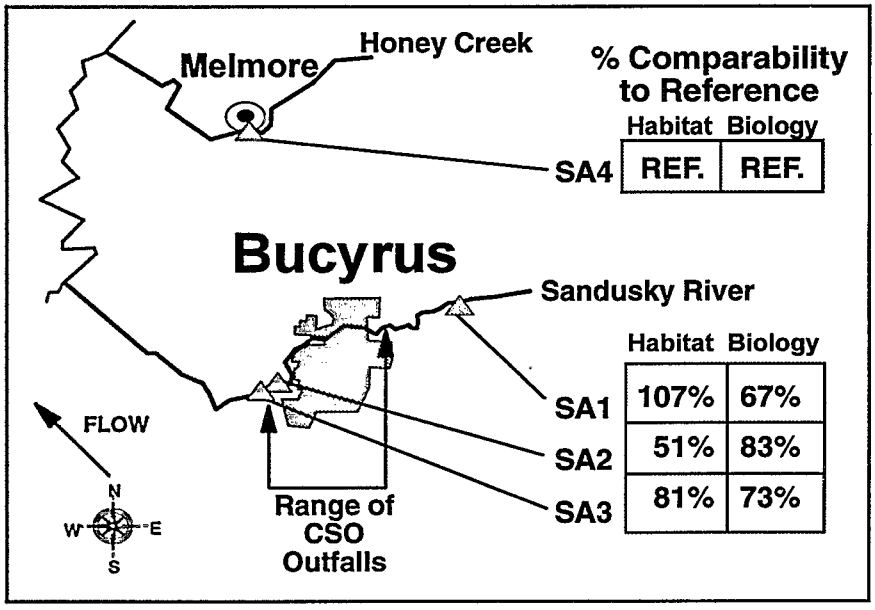

Figure 4. Sandusky River at Bucyrus; percent comparability of sampling sites to reference condition.

suspended organic particulates. The upstream reference station (S1) exhibited only slight impairment, likely due to other human activities occurring upstream and adjacent to this station.

The Sandusky River is a major tributary to Lake Erie, running through predominantly agricultural land in north central Ohio (Figure 1). Past biological monitoring of the Sandusky River at Bucyrus revealed significant impacts to the fish and macroinvertebrate communities from CSOs and the Bucyrus wastewater treatment plant (WWTP). Improvements in the biota were reported in 1990, subsequent to upgrades at the WWTP; however, slight biological impairment remains. Results of the current study indicated only slight impairment of the macroinvertebrate community at the downstream CSO-receiving station (SA3), which agreed with Ohio EPA historical data (Figure 4). Impairment appears to be due to a combination of habitat degradation and associated water quality impacts.

The Little Cuyahoga River flows through Akron in northeastern Ohio, where it joins with the Cuyahoga River (Figure 1). The study area extends from downstream of the Mogadore Reservoir to just upstream of the Cuyahoga River confluence. Past sampling by Ohio EPA indicated "fair" and "poor" biotic conditions due to a combination of urban runoff and enrichment problems from lake and wetland drainage. In the current study, the Little Cuyahoga was found to exhibit moderate biotic impairment at the station farthest downstream (CR3) while the upstream station (CR2) was nonimpaired (Figure 5). (Sampling at Ohio EPA's regional reference site was not possible due to flood conditions, so comparisons are possible only with the site-specific reference.) Habitat conditions were somewhat degraded, but comparable at all three sites, so biological impairments at the furthest downstream station (CR3) can be attributed to water quality. There was a distinct depression in overall biological condition including decreases in abundance and low diversity. These conditions may indicate the presence of toxicants contributed by CSO and/or industrial inputs. The first downstream station (CR2) was originally expected to be CSO-impacted. However, given our study results, we further investigated the history of the CSOs and discov-

ered that the outfalls upstream of the middle station had been recently eliminated. The biotic improvement shown here reflected their removal.

Conclusions

Three CSO sites with varying degrees of historical information were identified by the Ohio EPA. Results of the present study agree favorably with most of the recent findings of Ohio EPA and demonstrate the usefulness of bioassessments in identifying impaired waters.

Objective 1: Evaluating Biological Impact of CSOs

Attributing "cause-and-effect" to the specific CSO activity is complicated by other related problems associated with urbanization, e.g., habitat alteration and industrial discharges. However, reasonable technical support for identifying potential sources, including CSOs, was possible with bioassessments. An impairment due to CSO outfalls was noted in biological data collected by both Ohio EPA and U.S. EPA (this study) for a 15-20-mile reach of the Scioto River, a 4-mile reach of the Sandusky River, and a 10-mile reach of the Little Cuyahoga River. In the cases of the Scioto and Little Cuyahoga Rivers, the upstream stations, also located in urbanized areas, had relatively healthy biological communities and were effective for comparisons showing that CSO outfalls had an adverse impact on the macroinvertebrate assemblage. Results from the Sandusky River indicated that the CSO outfalls are having only slight biological impacts due to secondary controls that had been installed.

Objective 2: Determining the Usefulness of RBPs in Detecting Those Effects

The bioassessments were instrumental in identifying impaired reaches of each river at periods that reflected residual and cumulative effects of CSO outfalls that were not necessarily active. Sampling was performed during normal low-flow conditions. The associated habitat assessment enabled a characterization of the alteration to the physical habitat structure that strengthens the ability to identify additional potential sources of impairment.

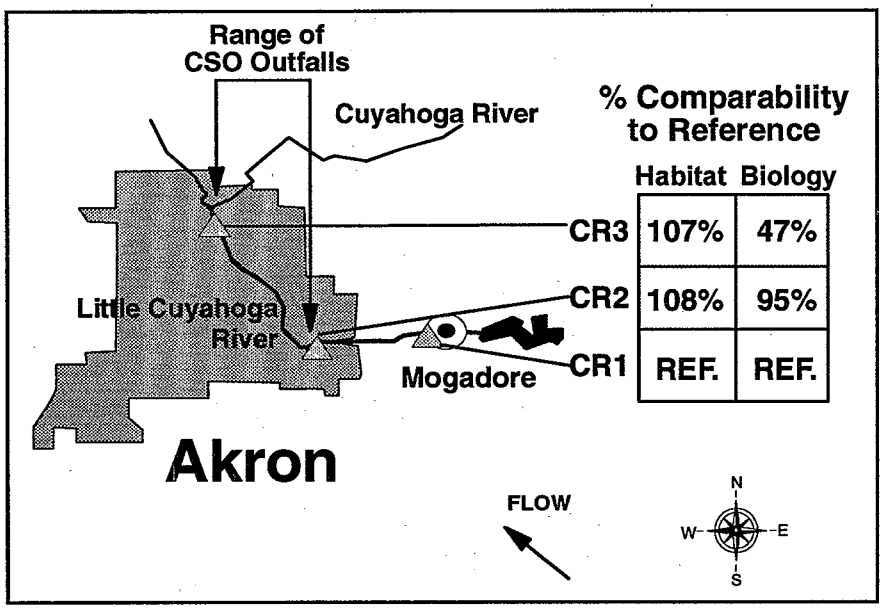

Figure 5. Little Cuyahoga River at Akron; percent comparability of sampling sites to reference condition.

Objective 3: Comparison of RBP Results with Ohio EPA Historical Data

A comparison of results suggested that a reasonably good fit between Ohio EPA findings and that those of the present study. Subtle discrepancies between the data sets are most likely a result of the lack of regional calibration for the RBP analysis technique that may have weakened the interpretive power of the approach. Bioassessment, as exemplified by the Ohio EPA ICI (an index for macroinvertebrates) and the RBPs applied in this study, is a valid and technically-sound tool for evaluating impaired waters, particularly when calibrated on a regional level as is done for the ICI.

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Application of Nonpoint Source Loading Relationships to Lake Protection Studies in Denver, Colorado

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Estimating nonpoint source pollution loading is an important element of watershed management. Loads must be quantified to determine to what extent nonpoint source pollution presents a problem in a particular watershed and to plan for solutions. For the purpose of this paper, nonpoint source loading is that pollution loading originating from surface flow runoff during storms and baseflow conditions in watersheds comprised of urban and nonurban land uses.

Various approaches are available to estimate nonpoint source loads from watershed areas. To provide useful results for watershed planners, these approaches must represent changes in watershed conditions over time. It is generally necessary to estimate loads for predevelopment watershed conditions, existing conditions, and anticipated future development conditions. This places current loading in the context of the watershed's history; the magnitude of projected loading relative to changes that have already taken place can then be considered. Also, load estimating approaches need to reflect projected load reductions that would result from the implementation of best management practices (BMPs). Load reduction predictions may consist of applying representative percent removal values found in the literature or may be estimated deterministically, based on the physical processes involved in the BMPs.

The purpose of this paper is to assist those involved in watershed management with their selection of one or more options for estimating nonpoint source loads. Therefore, 10 options for estimating nonpoint source loads, each fulfilling the objectives stated above, are compared here. The options consist of various levels of analyses, using four general methods available for estimating loads. The options examined range from simple calculations to approaches based on comprehensive hydrologic modelling and site-specific monitoring. A number of these options have been used effectively in lake protection studies in the Denver area. The 10 options, designated A through J, are shown in Tables 1 and 2. Table 1 indicates the general method and level of analysis represented by each option. Table 2 lists the major components of each option and discusses how the option is applied, how the option reflects changes in watershed conditions and BMP load reductions, and option benefits and limitations. Complete water quality simulation models such as SWMM, HSPF, and STORM represent a higher degree of

Table 1. Options for estimating nonpoint source loads

	Unit Load Method	EMC Method	Regression Method	Sediment Method
Level 1. Average Annual Values	Option A	Option B	Option E	Option H
Level 2. Single Storm Basis	N/A	Option C	Option F	Option I
Level 3. Single Storm Basis with Site Monitoring	N/A	Option D	Option G	Option J

Table 2. Comparison of load estimating options

Opt.	Handling Changes	Handling Changes in Watershed Over Time	Handling BMP Load Reductions	Benefits	Limitations
A	1. Unit loading factors for watershed land uses 2. Land use areas (Find product of 1 and 2, above, and sum load for various land uses)	1. Change land use areas to represent historic, current and future conditions	1. Multiply total annual loads by estimated BMP removal efficiency	1. Simple to apply 2. Quick results possible	1. Limited guidance available regarding selection of appropriate unit loading rate from range in literature 2. Results not sensitive to variations in rainfall depth or intensity, or specific physical characteristics of watershed 3. Limited information on unit rates for land disturbed by construction
B	1. Constant EMCs for watershed or EMCs representative of watershed land uses 2. Land use areas 3. Percent runoff curve based on percent imperviousness of land use from NURP or other source 4. Annual rainfall depth (Find product of 1, 2, 3 and 4, above, and sum for various land uses)	1. Change land use areas to represent historic, current and future conditions	1. Multiply total annual loads by estimated BMP removal efficiency	1. Simple to apply 2. Quick results possible	1. Limited guidance available regarding selection of appropriate EMC from range in literature 2. Constant EMC not sensitive to variations in depth or intensity of individual storms, or physical characteristics of watershed 3. Limited information on EMCs for land disturbed by construction 4. NURP runoff curve not sensitive to storm depth or intensity, basin size or infiltration capacity, and tends to overestimate runoff
C	1. Constant EMC for watershed 2. Hydrology model of watershed 3. Series of single storm events, either range of return periods or representative storms from rainfall record (Use 2 and 3, above, to estimate runoff volume, multiply by 1, above, and convert to annual load using return period or rainfall record approach)	1. Change hydrologic model to represent historic, current and future conditions	1. Multiply total annual loads by estimated BMP removal efficiency	1. Runoff estimate using watershed-specific hydrology model reflects effects of storm depth and intensity, basin size, and infiltration capacity	1. Limited guidance available regarding selection of appropriate EMC from range in literature 2. Constant EMC not sensitive to variations in depth or intensity of individual storms, or physical characteristics of watershed. 3. Limited information on EMCs for land disturbed by construction 4. Greater data needs and time commitment than Level 1 analysis

Table 2. (continued)

Opt.	Handling Changes	Handling Changes in Watershed Over Time	Handling BMP Load Reductions	Benefits	Limitations
D	1. Watershed-specific monitoring program 2. Measured EMCs representative of baseflows and storm runoff 3. Measured annual volumes of baseflows and storm runoff 4. Hydrology model of water-shed 5. Series of single storm events, either range of return periods or representative storms from rainfall record (Find product of 2 and 3, above, to estimate load for current, conditions, calibrate 4 and 5, then use 4 and 5 to estimate runoff volume and loads for historic and future conditions, and convert to annual load using return period or rainfall record approach)	1. Calibrate hydrologic model to measured flows for current conditions, then change model to represent historic and future conditions	1. Multiply total annual loads by estimated BMP removal efficiency	1. Measured EMCs and runoff volumes, accounting for baseflows and calibration of hydrologic model provides higher level of accuracy than Level 1 or 2 analyses	1. Greater data needs and time commitment than Level 2 analysis for design and implementation of site-specific monitoring program
E	1. Regression equations for annual load, such as in Driver and Tasker, 1990 2. Regression variables such as watershed area, percent imperviousness, mean annual rainfall, and mean January temperature (Solve regression equation to estimate loads)	1. Change percent imperviousness to represent historic, current, and future conditions	1. Multiply total annual loads by estimated BMP removal efficiency	1. Simple to apply 2. Quick results possible	1. Results not sensitive to variations in depth or intensity of individual storms, erodibility of watershed, or extent of construction disturbance
F	1. Regression equations for single-storm load or EMC 2. Regression variables 3. Hydrology model of watershed 4. Series of single storm events, either range of return periods or representative storms from rainfall record (Use 3 and 4, above, to estimate runoff volume, apply 1 and 2, above, and convert to annual load using return period or rainfall record approach)	1. Change hydrologic model and values of regression variables to represent historic, current, and future conditions	1. Multiply total annual loads by estimated BMP removal efficiency	1. Runoff estimate using watershed-specific hydrology model reflects effects of storm depth and intensity, basin size and infiltration capacity 2. Selection of EMC more deterministic than picking literature value as in Option C	1. Greater data needs and time commitment than Level 1 analysis

Table 2. (continued)

Opt.	Handling Changes	Handling Changes in Watershed Over Time	Handling BMP Load Reductions	Benefits	Limitations
G	1. Watershed-specific monitoring program 2. Regression equations for single-storm and baseflow load or EMC developed 3. Regression variables 4. Hydrology model of watershed 5. Series of single storm events, either range of return periods or representative storms from rainfall record (Apply 2 and 3, above, to estimate load for current conditions, calibrate 4, then use 4 with 2 and 3 to estimate loads for historic and future conditions, and convert to annual load using return period or rainfall record approach) from 1, above	1. Calibrate regression equation and hydrologic model to measured data for current conditions, then change regression variables and hydrologic model to represent historic and future conditions	1. Multiply total annual loads by estimated BMP removal efficiency	1. Regression EMCs and runoff volumes, accounting for baseflows, and calibration of regression equations and hydrologic model provides higher level of accuracy than Level 1 or 2 analyses	1. Greater data needs and time commitment than Level 2 analysis for design and implementation of site-specific monitoring program and statistical analysis to develop regression equations
H	1. Annual estimate of sediment eroded from watershed using unit load approach 2. Annual estimate of sediment eroded from stream channels 3. Constituent content of sediment eroded from watershed 4. Constituent content of sediment eroded from streams 5. Ratio of suspended form of constituent to total constituent concentration (Sum the products of 1 and 3, above, and 2 and 4, above, and divide by unity less 5, above, to estimate total annual constituent load)	1. Use annual estimates of sediment eroded from watershed and stream channels that represent historic, current, and future conditions	1. Use annual estimates of sediment eroded from watershed and stream channels that represent effect of BMPs or multiply total annual loads by estimated BMP removal efficiency	1. Simpler to apply than Level 2 or 3 analyses 2. Quicker results possible than Level 2 or 3 analyses 3. Effect of BMPs on loads more deterministic than Options A through G	1. Limited information available regarding constituent content of sediment 2. Unit sediment yield not sensitive to variations in depth or intensity of individual storms, or specific physical characteristics of watershed
I	1. Single-storm approach to estimating sediment eroded from watershed, such as Modified Universal Soil Loss Equation (MUSLE) 2. Annual estimate of sediment eroded from stream channels 3. Constituent content of sediment eroded from watershed 4. Constituent content of sediment eroded from streams 5. Ratio of suspended form of constituent to total constituent concentration	1. Change hydrologic model MUSLE variables and stream erosion estimate to represent historic, current, and future conditions	1. Physical processes involved in most BMPs can be incorporated into net sediment yield and stream erosion calculations	1. Effect of BMPs on loads more deterministic than Options A through H	1. Limited information available regarding constituent content of sediment 2. Greater data needs and time commitment than Level 1 analysis

Table 2. (continued)

Opt.	Handling Changes	Handling Changes in Watershed Over Time	Handling BMP Load Reductions	Benefits	Limitations
I (cont)	6. Hydrology model of watershed 7. Series of single storm events, either range of return periods or representative storms from rainfall record (Use 6 and 7, above, to estimate runoff characteristics, apply 1, above, and convert to annual yield using return period or rainfall record approach, then sum the products of yield and 3, above, and 2 and 4, above, and divide by unity less 5, above, to estimate total annual constituent load)				
J	1. Watershed-specific monitoring program 2. Measured sediment loads from watershed and stream erosion 3. Single-storm approach to estimating sediment eroded from watershed, such as MUSLE 4. Procedure for estimating annual quantity of sediment eroded from stream channels 5. Measured constituent content of sediment eroded from watershed 6. Measured constituent content of sediment eroded from streams 7. Ratio of suspended form of constituent to total constituent concentration 8. Hydrology model of watershed 9. Series of single storm events, either range of return periods or representative storms from rainfall record (Use 8 and 9, above, to estimate runoff characteristics, apply 3, above, calibrate for current conditions using 2, and convert to annual yield using return period or rainfall record approach, then calibrate 4, above, sum the products of yield and 5, above, and 4 and 6, above, and divide by unity less 7, above, to estimate total annual constituent load)	1. Calibrate sediment estimates and hydrologic model to measured data for current conditions, then change sediment estimates and hydrologic model to represent historic and future conditions	1. Physical processes involved in most BMPs can be incorporated into net sediment yield and stream erosion calculations	1. Effect of BMPs on loads more deterministic than Options A through H 2. Measured constituent contents in sediment overcome limitations in literature values	1. Greater data needs and time commitment than Level 1 or 2 analyses for design and implementation of site-specific monitoring program

complexity than the options compared in Tables 1 and 2. In cases where a high degree of precision in load estimating is desired, complete simulation models may be considered. Documentation for these models is readily available (USEPA, 1991). The following paragraphs provide background information on general load estimating methods and levels of analysis.

Load Estimating Methods

Four general methods for estimating nonpoint source loads comprise the basis of the individual options discussed in this paper. These are the unit load method, the event-mean-concentration (EMC) method, the regression method, and the sediment method (USEPA, 1991). Each method results in an annual estimate of the mass of a constituent generated by the upstream watershed. Units for load estimates are typically gm/yr or mt/yr (lb/yr or t/yr).

Unit Load Method. Nonpoint source loads in the unit load method are expressed as the product of a unit loading rate and upstream drainage area. The unit loading rate, also known as an export coefficient, is a value of mass per area per time (gm/m/yr or mt/ha/yr [lb/ac/yr or t/ac/yr]) representative of average watershed conditions. Unique unit loading rates are often associated with specific watershed land uses, such as industrial, residential, or rural areas (Rast and Lee, 1983).

EMC Method. Watershed loads in the EMC method are expressed as the product of the constituent concentration (often flow-weighted) and the runoff volume. Constituent concentrations may be median or mean values of local, regional, or national storm water monitoring data, often correlated to land use (USEPA, 1983). Runoff volumes may be assumed percentages of annual rainfall amounts, annual sums of estimated single-storm event runoff, or measured runoff volumes.

Regression Method. Watershed loads in the regression method are estimated using regression relationships developed from local, regional, or national storm water monitoring data. Regression relationships are based on variables relating to physical watershed or rainfall characteristics that are statistically significant. Regression relationships may compute constituent load directly or may predict pollutant EMCs, in which case the EMCs must be multiplied by annual runoff volume to estimate loads (Driver and Tasker, 1990).

Sediment Method. The sediment method is essentially the same as the EMC method, only applied to the quantity of sediment, not water, generated by a watershed. Pollutant loads in the sediment method are expressed as the product of the constituent concentration in eroded sediments and the quantity of sediment delivered by a watershed on an annual basis (Tim et al., 1992). The constituent concentration in sediment, also known as the content or potency factor, is expressed as the mass of the constituent to the mass of sediment. Concentration values consist of locally measured data. Sediment loads may be measured or calculated values representative of the watershed. The sediment method is most appropriate for constituents having an affinity for sediment adsorption, such as nutrients, metals, and radionuclides. The method is suited to watersheds where sediment yield is a significant source of nonpoint loading and the ratio of suspended to dissolved constituents is high. These conditions generally represent the Denver area and the rest of the semi-arid western United States. Suspended loads estimated using the sediment method can be adjusted (divided by unity less a fraction of suspended to total constituent forms) to represent total load.

Levels of Analysis

Methods used to estimate nonpoint source loads can be applied in various levels of detail. These levels of analysis range from simple calculations (taking a minute or two to complete) to comprehensive approaches requiring significant data collection and hydrologic modelling (taking months to complete). For the purpose of this paper, these levels have been grouped into three types of analyses:

- Level 1—Average Annual Values
- Level 2—Single Storm Basis
- Level 3—Single Storm Basis with Site Monitoring

Level 1 consists of using average annual values for unit loading, concentration, volumes of runoff or sediment, or regression variables. The annual values may be representative of the watershed as a whole, or of unique land use areas within the watershed.

Level 2 is based on computing loads for single storm events and summing the loads for a representative annual storm pattern. Annualizing individual storm loads can be accomplished using one of two approaches. The first approach involves examining single storm events, which can comprise design storms in a series of return periods, such as 2-, 5-, 10-, 50-, and 100-year events. Loads for these storm events can be plotted versus storm probability (the inverse of return period (for instance, 0.50, 0.20, 0.10, 0.02, and 0.01) for the return periods identified above). The area under the load probability curve can be measured or calculated to represent a long-term average annual load (ADWR, 1985). Sediment and sediment-adsorbed constituent loads are highly dependent on the size and intensity of rainfall events; therefore, a significant portion of the long-term loads may be generated during a few large, infrequent events. (This phenomenon may be more pronounced in the semi-arid West than other climatic regions of the United States.) The return period analysis would offer the benefit of factoring the effect of large, infrequent storms (such as the 100-year event). However, actual constituent loads in most years (assuming average rainfall) would be less than long-term average estimates using this approach.

A second and somewhat more complex approach is available for converting single-storm event loads to an average annual load. This approach involves using long-term records of local rainfall to identify actual storm hyetographs for the period of record (CH2M HILL, 1992). A manageable number of the largest, most intense storms may be used as the basis of single-storm load estimates. The numerous smaller storms may be sorted and categorized by size, and then represented by a single storm for each category. These representative storms can be used as the basis of load estimates, which, when multiplied by the number of storms in each category, would equal total loads by category. The sum of the loads for all the storms in the rainfall record divided by the number of years of the record is representative of a long-term average annual load. This approach is most suitable for geographic areas that have a long rainfall record available (30 years or more). Like the return period approach, using the long-term local rainfall record has the benefit of factoring the effect of large, infrequent storms that have occurred during the period of record.

Whether the design storm approach or the rainfall record approach is used to annualize loads, the single storm event basis of Level 2 allows constituent loads to be estimated in a more deterministic manner than Level 1. On the other hand, the data needs and time requirements to conduct a Level 2 analysis are substantially greater than for a Level 1 analysis.

Level 3, like Level 2, is based on computing loads for single storm events and summing the loads for a representative annual storm pattern. Level 3, however, uses site-specific monitoring data to calibrate the single-storm load estimates. As such, the load estimates resulting from a Level 3 analysis will likely match actual watershed loads more consistently and closely than the results of Level 2 or Level 1 analyses. Compared to Level 2, additional time and effort would be required to design and conduct a site-specific monitoring program.

Application Guidelines

When using Tables 1 and 2 to select a specific option to estimate watershed loading, it is important to keep in mind the trade-offs between simplicity and precision. Level 1 approaches can be used to generate a load estimate quickly and simply; however, the lack of sensitivity to physical hydrologic processes and site-specific data creates a high degree of uncertainty in the results. There is a positive correlation between the reduction of uncertainty and the amount of complexity and time involved in the approach. Level 2 analyses can reduce uncertainty in load estimates by factoring in the hydrologic processes involved in individual storm events. Improving the estimation of watershed hydrology, especially the relative contributions of baseflows and storm runoff, is an effective means of increasing the precision of nonpoint load estimates. Level 3 analyses further improve precision and accuracy by calibrating results using site-specific monitoring data. If the degree of precision warrants, complete water quality simulation models may be prepared.

Because of their simplicity, it would be reasonable to apply one or more of the Level 1 analyses to a watershed to develop an initial range of load estimates. Using multiple approaches provides insight into

the correlation (or lack thereof) between assumed values used for response variables. It is important to establish the relative importance of sediment processes to the watershed and constituents in question. From this point of reference, it is recommended that one or more options representing higher levels of analysis be pursued, based on the degree of precision desired by watershed managers. Using combinations of methods or multiple approaches, can improve the selection of response variables. One strategy for enhancing efficiency in estimating loads is to apply a detailed approach in a representative area of a watershed, then use the results to "calibrate" Level 1 loading values for application to the rest of the watershed.

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Development of a Regional Framework for Storm Water Permitting in North Central Texas

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The North Central Texas Metroplex cities that must comply with the Federal Clean Water Act NPDES regulations for controlling pollutants in municipal separate storm sewer system (MS4) discharges have joined forces through the North Central Texas Council of Governments (NCTCOG) to pursue a regional approach that meets the technical, legal, and jurisdictional coordination needs of the regulations through a unified approach and which takes an important first step toward dealing with urban runoff from a watershed perspective rather than on a jurisdictional basis.

Seven cities in the Metroplex area with an aggregate population of 2.3 million are subject to the NPDES MS4 regulations—Arlington, Dallas, Fort Worth, Garland, Irving, Mesquite, and Plano. Additionally, the Texas Department of Transportation, the Home Builders Association, the Association of General Contractors, and numerous nondesignated cities in the region are participating in the regional effort. These cities and agencies, working together through NCTCOG, selected a regional consultant team headed by Camp Dresser & McKee Inc. to provide assistance on coordinated needs to ensure consistency in technical approach and supporting legal authority for addressing storm water quality management on a regional basis.

Area cities, working with the regional consultant through NCTCOG, reached consensus on an innovative and cost-saving regional strategy that addresses the following major permit application development issues:

- Coordination of permit application submittals.
- Regional water quality assessments in association with the U.S. Geological Survey (USGS).
- Assessment of funding alternatives to support program implementation.
- Development of model instruments for legal authority (an ordinance and interjurisdictional agreements).
- Development of best management practice (BMP) manuals for residential, commercial, and industrial land uses and for construction site management.
- Selection and application of watershed management models for estimation of discharge pollutant loads/concentration and for evaluation of pollution management plan alternatives.
- Development of technical, institutional impact, and cost-effectiveness

criteria for selection of management plan alternatives.
- Public information/involvement for the North Central Texas region to inform the populace on the NPDES storm water mandate, and on what actions individual citizens may take to reduce pollutants in storm water runoff and to report possible illegal discharges.

Each of these efforts was developed with technology transfer to municipal staff as the ultimate goal, allowing cities to more effectively address permit application submittals and post-permit issuance compliance needs.

Regional Coordination

Since Texas is a nondelegated state, negotiations have been conducted with EPA Region VI to develop a unified MS4 permitting approach for the Cities of Arlington, Dallas, Fort Worth, Garland, Irving, Mesquite, and Plano, Texas, that, because of size and census date, had three different permit application deadlines (November 1992, May 1993, and August 1993). The unified approach provides the needed environment for coordination and cooperation among the cities (and other agencies involved) to accomplish NPDES permit applications that are consistent, technically sound, and fiscally responsible.

EPA Region VI strongly supports coordination in permitting efforts. While the seven municipalities must still submit significant portions of their Part 2 applications by their original designated deadlines, several components of their applications were consolidated under a unified deadline to facilitate regional programs. Because the State of Texas does not, at present, have regulations or agency support for urban runoff and because county governments in Texas typically do not have a great deal of legal authority, NCTCOG (a regional planning agency) became the focal point of the regional storm water effort.

Through NCTCOG, the cities in the region (regulated and nonregulated alike) have created a Regional Urban Storm Water Task Force with two subcommittees to deal with storm water quality and development/management issues. The Task Force and its subcommittees are composed of municipal staff who manage storm water issues. NCTCOG coordinates the efforts and acts as a clearinghouse for information.

Regional Efforts

The major focus of the regional efforts is the development of an iterative process designed to configure and assess proposed management plans (PMPs) for managing urban storm water quality in light of current and anticipated future land use conditions. The overall process is structured to arrive at the optimal combination of BMPs for each municipality's PMP and is illustrated in Figure 1. There are four essential elements to this process: (1) development of regional BMP manuals for construction activities, industrial land uses, and residential/commercial land uses; (2) selection and application of a regional watershed model to determine

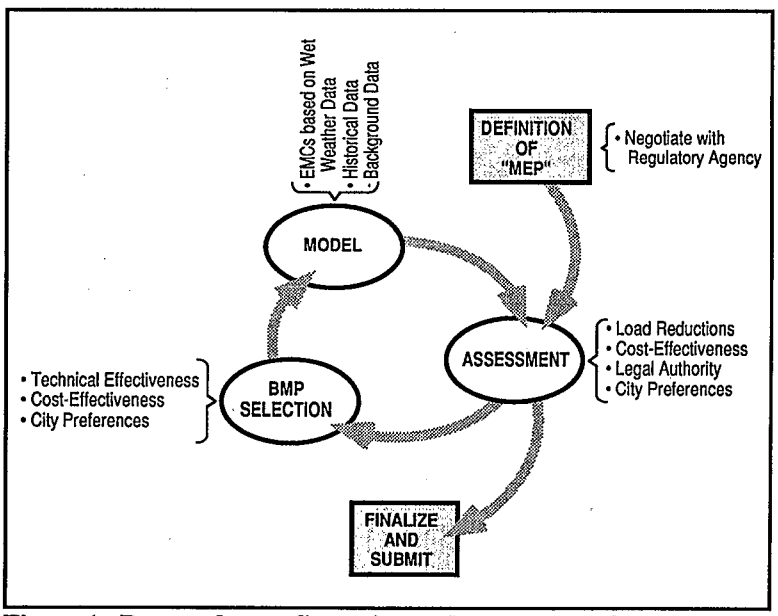

Figure 1. Process for configuration and assessment of proposed management plans.

pollutant loads/concentrations and to evaluate BMP alternatives; (3) technology transfer to municipalities on the use of the BMP manuals and the watershed model; and (4) providing assistance to cities in applying the manuals and models to develop their individual PMPs. In addition, public information, discharge characterization, and legal authority efforts are being addressed regionally

Construction Activities BMP Manual

For management of runoff quality from construction sites, a regional BMP manual (including standard details and specifications) has been produced and will include a training curriculum. The construction site runoff management program is designed to achieve regional consistency in the use, implementation, and maintenance of construction site BMPs for the North Central Texas area. The manual focuses on compliance with the NPDES General Permit for Construction Activities. It provides innovative means to assess the anticipated effectiveness of the erosion and sediment control aspect of Storm Water Pollution Prevention Plans (SWPPPs). Using effectiveness criteria established in the BMP manual, a rating factor can be calculated for an SWPPP. On a pass/fail basis, this allows cities in the region to review plans more consistently.

Because of the wide applicability of the General Permit, NCTCOG was able to convince those cities in the region not under the NPDES mandate to help offset the costs associated with this effort. NCTCOG and member cities will distribute this manual to owner/operators in the area for a nominal cost. NCTCOG is also endeavoring to establish long-term training programs on the use of the manual.

Industrial Activities BMP Manual

In addition to the construction activities manual, a BMP manual for industrial activities has been developed to assist area industries in meeting the General Permit for Industrial Activities. The manual has a pollution prevention orientation by encouraging consideration of source controls first, although a full discussion of treatment alternatives is provided. As with the construction activities BMP manual, the industrial BMP manual provides guidance in developing SWPPPs, provides information on source and treatment BMPs, and discusses monitoring options. NCTCOG and member cities will distribute this manual to area industries for a nominal cost and long-term training for this manual is being considered as well.

Residential/Commercial Land Uses BMP Manual

A third BMP manual for residential/commercial land uses has been produced to provide selection/design/performance criteria for both source control and structural treatment control management practices appropriate to the area and to provide further guidance to municipalities as they develop their PMPs. As with the industrial BMP manual, fact sheets on source and treatment BMPs appropriate for the North Central Texas region are provided along with methodologies for selecting BMPs and guidance on building a storm water quality management program. BMPs are coordinated with the regional watershed model (discussed later), and the manual also discusses options for compliance monitoring.

Assessment of Existing Conditions and Proposed Management Programs

A consistent methodology for assessing the pollution abatement performance of PMPs is also being developed—again for regional consistency. The foundation of this methodology is a storm water model for estimating pollutant discharge concentrations and loads and for evaluating management plan alternatives (such as source and treatment controls). Major public domain storm water quality management models were reviewed in terms of input data requirements, ease of use, ability to model management practice pollution control performance, and model output detail. Cities will apply the selected model in-house and, with guidance, are developing their own PMPs based on cost-effectiveness, technical effectiveness, administrative burden, and public acceptance.

The Watershed Management Model (WMM) developed by Camp Dresser & McKee Inc. was selected for use by the region. Originally developed for Florida's Department of Environmental Regulation, WMM has been significantly upgraded for the NPDES storm water permitting process. WMM simulates annual/seasonal storm water discharge pollutant loadings/concentra-

tions as a function of land use, and the model can simulate the pollutant control effectiveness of alternative BMP implementation scenarios. The model is spreadsheet-based and relies on land use-related pollutant event mean concentrations (EMCs) and annual/seasonal rainfall-to-runoff conversion coefficients to generate combined land use storm water discharge pollutant loadings and concentrations. The model can simulate the statistical EMC and loading exceedence values associated with the expected variance of specific land use-related storm water discharge EMC data. The model can simulate BMP implementation scenarios through specification of BMP pollutant removal performance and watershed areal extent of BMP application.

One reason WMM was selected by the cities is that it is user-friendly. Cities desired the ability to take the model in-house for use during the permit application process and as a planning tool in the future. The regional consultant has produced a user's manual for the model and provided extensive training to municipal staff who will use the model. Through NCTCOG, the cities agreed on regional input data for WMM (impervious percentages for land use types, EMCs, and BMP efficiencies) for consistency and equity. The region will also use WMM as one means to estimate existing loads.

Wet Weather Discharge Characterization

The USGS is working with area cities to collect and analyze discharge quality for 210 storm events in the region (30 sites, 7 events each). Monitoring sites have been located in areas of new and residential land use, industrial land use, commercial land use, and major roadways. To date, over 170 events have been sampled and reported. The regional consultant team is analyzing those data and will create a set of EMCs for the region.

Because current wet weather discharge water quality data are being collected in a period of unusually high rainfall, the regional consultant is also looking at historical wet-weather receiving water quality data for the region. This provides an additional perspective on historical water quality critical to justifying the performance of the management plans municipalities must propose as a part of their NPDES permit applications. Available surface water quality data from local municipalities, the State of Texas, and federal agencies are being reviewed in comparison to rainfall records to determine which data are representative of discharges or in-stream flows during storm events. Without this separation of data types, no meaningful interpretation can be made on storm water impacts to receiving waterways.

Legal Authority

Besides addressing the technical aspects of storm water quality management, efforts are being put forth to assist cities in the area of legal authority. Municipalities in the region typically have only minimal ordinance authority to control storm water quality. There was great interest among the cities for the development of a comprehensive model storm water ordinance, largely because of regional equity. Model interjurisdictional agreements with entities such as the Texas Department of Transportation are being produced as well. The model ordinance and interjurisdictional agreements are for cities to refine and adopt. Many components of these legal instruments have menu options for cities to select from as they refine and adopt them.

Public Information

In the area of public education, a number of regional public education efforts are being undertaken to make the public aware of storm water quality issues and actions individuals can take to improve storm water quality. Brochures, flyers, water bill messages, press releases, and articles are being produced for municipalities to use as they educate their citizenry and for use during the permit term. Visual aids, such as videos, slide shows, and standing exhibits (for malls, etc.), are also being produced as resources for these cities. Essay and poster contests at the school level are under way as well.

"Sticky" Issues

Not all aspects of storm water management can be agreed upon by municipalities. Because municipalities in the region have not dealt with the management of urban runoff quality previously, the NPDES storm water regulations have required city managers to adopt a "new" perspective on their drainage facilities.

The potential fiscal implications for city programs, coupled with the fact that only the larger of the area cities are currently regulated, has created a somewhat negative attitude toward storm water quality management in municipal staff.

Issues such as the regulation of development and industrial activities within these cities, the perceived lack of need for treatment controls, and costs associated with permitting spark a great deal of discussion among area cities. The principal challenge in the development of a cost-effective PMP is the goal established by the NPDES regulatory requirement to reduce storm water pollutants to the maximum extent practicable (MEP). To assist the decision-making (and eventually the negotiating) process for storm water managers, the regional consultant team provided discussions on many of these "sticky" issues surrounding MEP. Each of these discussions was designed to help cities develop PMPs that are rational and, above all else, cost-effective. One of the critical activities that the regional consultant is participating in is discussions with EPA Region VI on what constitutes MEP, based on consideration of receiving water quality conditions and fiscal constraints.

Benefits of Regional Coordination

Besides the benefits of regional consistency, participating municipalities are benefiting from the opportunity to develop management programs in-house and, as a result, are better prepared to address permit compliance and renewal issues. Area cities are also recognizing economic benefits through cost-sharing throughout the permit application development process. The largest potential fiscal benefit will be realized as the NPDES permits are implemented. By coordinating efforts and building strong relationships, the cities will more readily achieve the most cost-effective means to control storm water pollution on an integrated watershed management basis through the application of regionally consistent technical criteria and legal authority.

This successfully implemented unified approach provides significant benefits to the affected cities, including:

- Allowing comprehensive characterization of water quality data to support management program development.
- Providing an opportunity to establish unified BMP manuals for use by all of the affected cities, thereby ensuring equity and consistency.
- Allowing a cost-effective and consistent approach to storm water discharge control ordinance development.
- Providing sufficient opportunity to give full consideration to funding needs and available funding alternatives for comprehensive storm water management.
- Allowing for a coordinated approach for addressing coordination with non-municipal entities such as the Texas Department of Transportation.
- Allowing public information and participation programs to begin well ahead of management efforts, helping to ensure public acceptance.
- Providing better information on which to base continued monitoring efforts and BMPs throughout the life of the permits.

Conclusions

The goal of the regional urban storm water management activities is the development of a flexible and phased permit application development and compliance process that allows each municipality considerable freedom in developing and implementing its individual programs through the application of consistent technical criteria and supporting legal authority, based on integrated consideration of the following management practice selection criteria:

- Effectiveness to reduce pollutants.
- Cost-benefits comparison considering management/staff needs, equipment, and construction cost.
- Time to results—the time between practice implementation and the realization of significant pollutant reduction.
- Ability to implement—funding availability, legal authority needs, logistics, and jurisdictional issues.
- Public acceptability.
- Compatibility with other environmental management objectives.

The Metroplex cities will complete and submit their coordinated Part 2 permit applications to EPA Region VI in August 1993.

Agricultural Watershed Planning Over Shallow Ground Water

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Agricultural nonpoint source contamination of surface and ground water has been of increasing concern to scientists and the general public. The Rural Clean Water Program (RCWP) was initiated in 1977 to evaluate several objectives, one of which was to improve the impaired water use and water quality in approved project areas in the most cost-effective manner, consistent with the production of food and fiber (Smolen and Smith, 1989). South Dakota's project was one of five comprehensive monitoring and evaluation (CM&E) projects designed to monitor the effectiveness of the RCWP. The CM&E projects were selected for intensive monitoring and were designed to determine the cause-and-effect relationships between best management practices (BMPs) and water quality. Specifically, the South Dakota RCWP project intensively monitored ground water and the vadose zone at specific sites to evaluate the impact of BMPs on the shallow ground water and the water moving through the vadose zone toward the ground water.

From the site-specific monitoring activities, conclusions were drawn relating land use to water quality impacts. Of particular importance at the end of this project was that unless detailed subsurface geology was known within each of the watersheds where the sites were located, applying the results from the sites may not necessarily apply across the watershed. Interactions of surface and ground water, and run-on to monitoring sites from off-site activities, may have significant impacts when evaluating the entire watershed. The South Dakota RCWP project evaluated the impacts of a management practice on the movement of water to the ground water from certain precipitation events; it did not evaluate how a particular event impacted the surface vs. ground water or the trade-offs between the two for a given site—nor did it evaluate the impact of an event to both the surface and ground water for the entire watershed. This paper addresses the results obtained from this 10-year project that may have specific significance when applying these results to the entire watershed. Problems and instances of suspected cases of uncorroborated data are specifically discussed to heighten awareness of those who may need information in developing strategies for watershed management.

Discussion

Nitrate in Shallow Ground Water

In rural areas where row crops are abundant, nitrate contamination of surface and ground water from commercial nitrogen-based fertilizers is of particular concern. In shallow ground water systems, where the recharge is known to be from precipitation through the soil, there tends to be a stratification of nitrate-nitrogen (NO_3-N) with higher concentrations near the water table and decreases with depth (Oakwood-Poinsett Report, 1991). Figure 1 represents data from several subsurface geologies (geozones). The description of the geozones and the number of wells that were installed in each

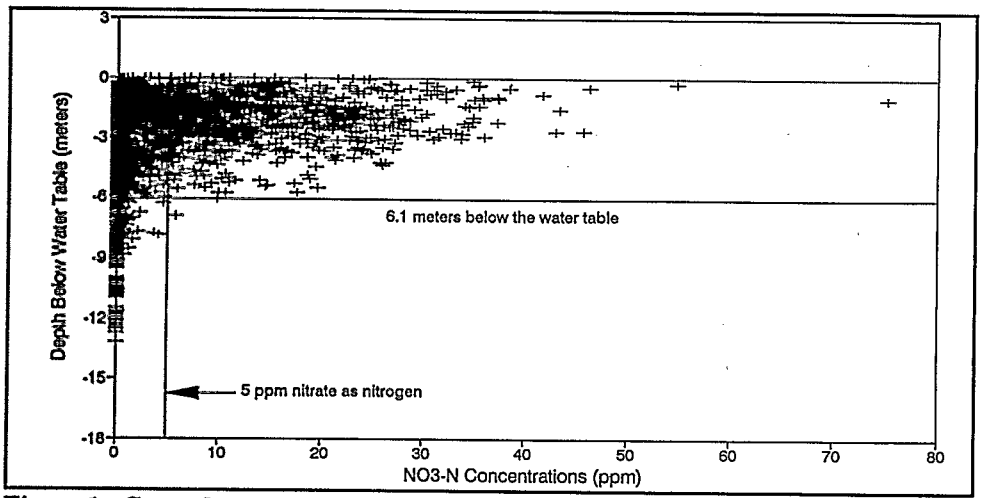

Figure 1. Ground water monitoring well nitrate-nitrogen concentrations of 3,092 samples from 106 wells collected between January 1984 and December 1990.

geozone for the South Dakota RCWP project are listed in Table 1. In the Oakwood Lakes-Poinsett RCWP area, all geozones exhibited the same trend of decreasing nitrate with increasing depth below water table. Table 2 shows the statistical data of the mean and median NO_3-N concentration for each geozone for the 10-year time frame. Three of the five highest median NO_3-N concentrations were taken from geozones with lower drainable porosities. This is probably attributable to the lower volume of water in the ground water that is present for dilution.

This implies that, if the shallow ground water is used for drinking water purposes, well(s) should be installed to remove water below the water table to limit the inflow of nitrates from near the top of the water table. In aquifers where the water can be economically pumped, and there is adequate depth of more porous material, the wells should be screened near the bottom of the material to ensure that the well does not go dry. This method may improve the quality of water pumped, and if future installations are considered, knowing this information may assist developers in locating wells

Table 1. Geozone abbreviations and definitions for the RCWP Saturated Zone Study

WTLT15	Weathered till (brown color) or silty clay (reworked till) with the screened interval of the well at a depth b.g.s. of less than or equal to 15 ft (4.6 m). (19 wells)
WTGT15	Weathered till or transition zone (greenish brown zone interpreted as a transition zone between the weathered and the unweathered till) with the screened interval at a depth b.g.s. of greater than 15 ft (4.6 m). (11 wells)
UT	Unweathered till (gray color). (7 wells)
SC	Silty clay aquitard located between an upper and a lower aquifer system. (2 wells)
SS-A	Alternating layers of thinly bedded fine sand and silt. (4 wells)
SGLT5LT10	Sand and gravel with less than or equal to 5 ft (1.5 m) of overlying soil material, with the screened interval less than or equal to 10 ft (3 m) below the water table. (30 wells)
SGLT5GT10	Sand and gravel with less than or equal to 5 ft (1.5 m) of overlying soil material, with the screened interval greater than 10 ft (3 m) below the water table. (15 wells)
SG5-15LT10	Sand and gravel with greater than 5 ft (1.5 m) and less than or equal to 15 ft (4.6 m) of overlying soil material, with the screened interval less than or equal to 10 ft (3 m) below the water table. (2 wells)
SG5-15GT10	Sand and gravel with greater than 5 ft (1.5 m) and less than or equal to 15 ft (4.6 m) of overlying soil material, with the screened interval greater than 10 ft (3 m) below the water table. (3 wells)
SGGT15	Sand and gravel with greater than 15 ft (4.6 m) of overlying soil material. (5 wells)
SG-UA	Sand and gravel located under an aquitard as the lower unit of a two aquifer system. (16 wells)

NOTES: Overlying soil material refers to all silt and clay rich sediments overlying a sand and gravel layer. It includes silt and/or clay loams and, in some cases, glacial till.
While it may appear the SGGT15 and SG-UA may both apply to a monitoring well, SG-UA specifies an aquitard between two sand and gravel units that both have some portion of their thickness saturated. SGGT15 only implies that there is 15 feet of overburden above the mentioned sand and gravel unit. If there is an upper sand unit, it was not saturated.

Table 2. Geozone statistical data for NO_3-N for the RCWP Saturated Zone Study

Geozone	No. of wells	N-Species	Minimum	Maximum	Median	No. of Samples	Mean
SS-A	4	NO_3-N	0.02	26.20	5.25	147	6.78
SG5-15GT10	30	NO_3-N	0.00	4.05	0.65	57	0.92
SGLT5LT10	15	NO_3-N	0.00	75.25	4.32	869	6.97
SGGT15	2	NO_3-N	0.00	4.07	0.03	730	0.24
SG-UA	3	NO_3-N	0.00	34.91	0.14	433	4.64
SGLT5GT10	5	NO_3-N	0.00	28.54	0.29	427	3.29
SC	2	NO_3-N	1.60	23.50	7.18	43	10.08
SG5-15LT10	16	NO_3-N	0.00	0.20	0.05	64	0.05
WTLT15	19	NO_3-N	0.00	54.75	7.03	504	9.96
WTGT15	11	NO_3-N	0.08	28.00	2.20	338	6.32
UT	7	NO_3-N	0.02	15.26	0.37	185	0.56

NOTE: Concentrations are in parts per million (ppm) of water, which is equivalent to milligrams per liter (mg/l).

properly to improve both quantity and quality in areas of shallow water where the major recharge is known to be from precipitation through the soil.

If shallow glacial till wells located in agricultural row crop areas are used for low-volume domestic use, it is important to understand that the concentrations of NO_3-N in this water can contain concentrations of NO_3-N higher than the drinking water standard of 10 milligrams per liter (mg/l).

Nitrates in the Vadose Zone

In the vadose zone study (Bjorneberg and Bischoff, 1989), on a Poinsett silt loam with a glacial-till clay loam subsoil, the trend for the NO_3-N concentrations for the moldboard plow tillage treatment was similar to the ground water results—decreasing concentrations of NO_3-N with increasing depth below the land surface (Oakwood-Poinsett Report, 1991). In 1990, in a year of above-normal precipitation, NO_3-N concentrations for both the no-tillage treatment and moldboard plow treatments were higher at the 1.2-m and 1.8-m depths than in 1989, when precipitation was 16 percent below normal. The no-tillage treatment showed results for both years that had a peak of higher average seasonal NO_3-N concentrations at the 1.2-m depth and lower concentrations at the 0.6-m and 1.8-m depth (Figure 2). This indicates that the moldboard plow system holds nitrates higher in the soil profile than the no-tillage system and results in higher concentrations.

In dealing with mass transport of NO_3-N toward the ground water, however, the concentrations of nitrates are only part of the story. Determination of mass flux of water to the water table is difficult to assess for any subsurface geology. Although the magnitude of the results of the analysis of water flux may not be completely accurate

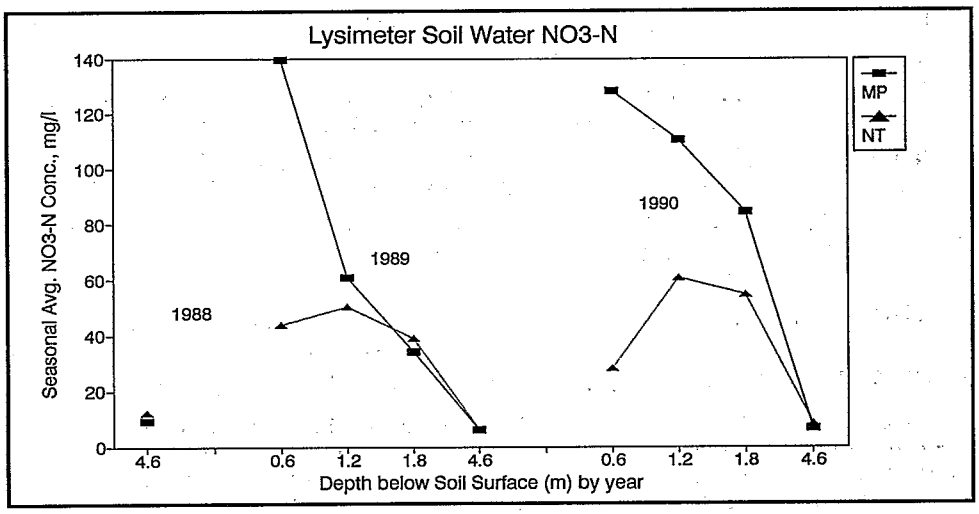

Figure 2. Mean seasonal nitrate-nitrogen concentrations of water collected from the RCWP vadose zone study for 2 years by depth for moldboard plow and no-till for corn and oats.

(using this method) relative to the "true" flux in these two systems, by using the *same* method to evaluate the two tillage systems, a relative comparison of the loadings may be quite good. For determining flux in glacial till soils, where there is substantial fluctuation of the water table, this method may be as good as any method for determining *total annual* loading of nitrates to the ground water.

It is necessary to know the average depth of water that moved to the ground water as well as the concentrations. The concentration of the solute multiplied by the mass transport of water gives total loading. Thus, Figure 3 (a-d) gives a more accurate picture of the loading of NO_3-N to the ground water over the season. Figure 3a shows a typical response of the water table to rainfall events on corn for 1989. Earlier in the season, the no-tillage system had higher total water moving to the water table (Figure 3b) but at lower concentrations of NO_3-N (Figure 3c) compared to the moldboard plow treatment. This translates to more loading of NO_3-N to the ground water for each leaching event (Figure 3d) for the no-tillage treatment. The total seasonal loading for 1989 (when precipitation was 16 percent below normal) was 23 kg/ha for no-tillage and 11 kg/ha for moldboard plow when broadcast-applied ammonium nitrate was used on corn at 225 kg/ha.

Although the broadcast method of applying fertilizers in high amounts did contribute to leaching for both moldboard plow and no-tillage treatments, the contribution was relatively low (4.2 percent and 10.2 percent of applied, respectively). For watershed planning to determine if the implementation of more conservation tillage will improve ground water quality, a question arises whether an increased 5 percent loading to the ground water offsets the reduced loading to surface water. In the 2 years of monitoring runoff from 5-meter by 11-meter plots in the vadose zone study, there was no significant differences in the runoff between tillage treatments for low and moderate precipitation events. There were two large events (7.6 cm and 13.3 cm) which washed out the border dikes, and runoff loading comparisons could not be made between the two tillage systems.

For the above case, the increased leaching for no-tillage would not be justifiable if the runoff loadings were the same. However, it is well known that conservation tillage (including no-tillage) reduces sediment loading and total water runoff. If more water is placed into the unsaturated soil reservoir for storage for no-tillage, less water is available for runoff or leaching for a given event compared to moldboard plow. By implementing conservation tillage over a greater area, for a given precipitation event, the specific surface and soil storage for rainfall is increased because the retention time of water on the soil surface is increased with subsequent increases in infiltration. Baker (1992) indicated that much more information is needed in the area of surface and ground water quality trade-offs, but that preliminary information points to the total increased benefits for water quality and that conservation tillage should be encouraged to protect water quality in general.

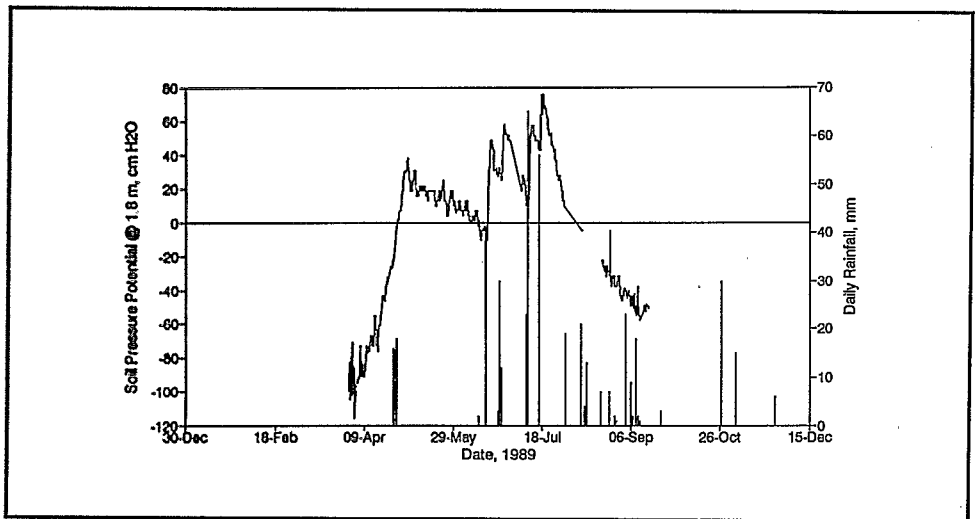

Figure 3a. Typical seasonal continuous water table levels as shown by a 1.8 m soil pressure potential monitoring device (transiometer) for 1989 on corn.

Pesticides in Shallow Ground Water

Pesticides in ground water from agrichemical use are becoming more frequent for two main reasons. First, the research and regulatory communities are looking for it more closely; and second, technology continually enables detection at lower concentrations. It should be emphasized that a pesticide's being detectable does not

mean that it is a problem for drinking water.

In the RCWP project, there were certain instances that indicated that a problem of runoff of adjacent water onto a ground water monitoring site took place carrying wash-off of a pesticide applied to a road ditch up-gradient of two wells. Tordon (picloram) was used to control leafy spurge in a ditch approximately 0.8 km from the monitoring well. There was no history of picloram use for that year at the ground water monitoring location; however, there was earlier spraying of picloram up-gradient to the site. This suggests that off-site runoff can have impacts on on-site-specific monitoring within watersheds in field situations.

In another case, at a specific ground water monitoring site, Sencor was detected three times in the same well during the summer months of sampling. There was no history of use of Sencor on the field, or any documented use of this herbicide on adjacent fields up-gradient of this site. All up-gradient fields were checked for any history of use, but it may point to an example of surface water carrying some contaminants to ground water some distance away.

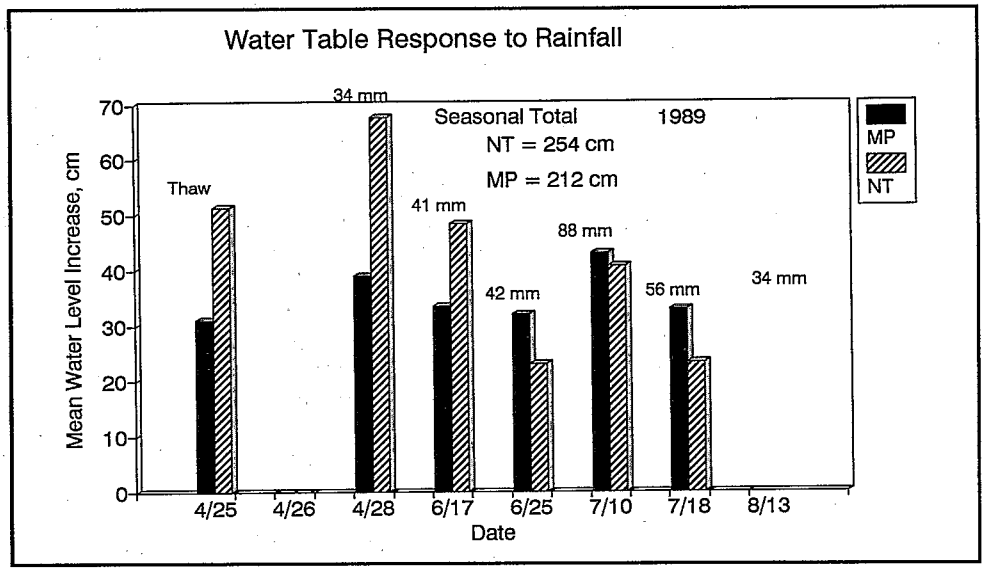

Figure 3b. Mean water level responses to rainfall/leaching events for the vadose zone study for two tillage treatments.

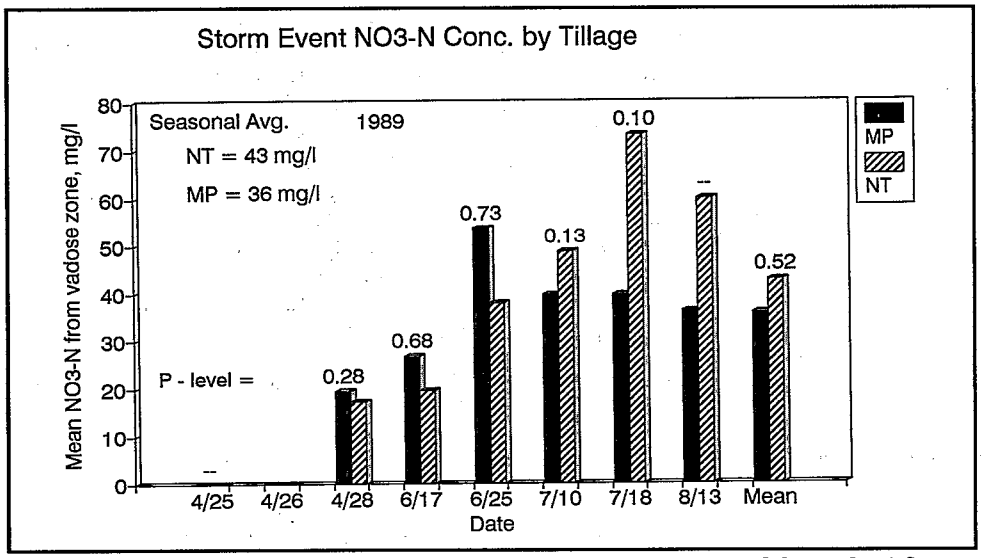

Figure 3c. Mean NO_3-N concentrations of water samples collected from the 1.8 m depth for individual rainfall events for the vadose zone study.

It is important to understand that the concentrations of pesticides that were carried with the water run-on in these two examples were not significantly high enough to pose a problem with drinking water. The mass loading of the pesticide to the ground water in these two cases could not be calculated from rhythmic water sampling and monitoring water levels. The depth of "new" water added to the system and an indication of the concentration levels of only the "new" water needs to be known before calculations of mass loading of a solute can be accurately determined. Because the concentrations of pesticides found were very low, near zero compared to NO_3-N concentrations, using water depth multiplied by concentrations to obtain an indication of ground water loading of the pesticide is not very reliable—not much more than a scientific guess.

This mechanism for transport of surface contaminants into subsurface waterbodies is real, however, and potentially can carry significant loading of agrichemicals to the ground water. The subsurface geology was different in each

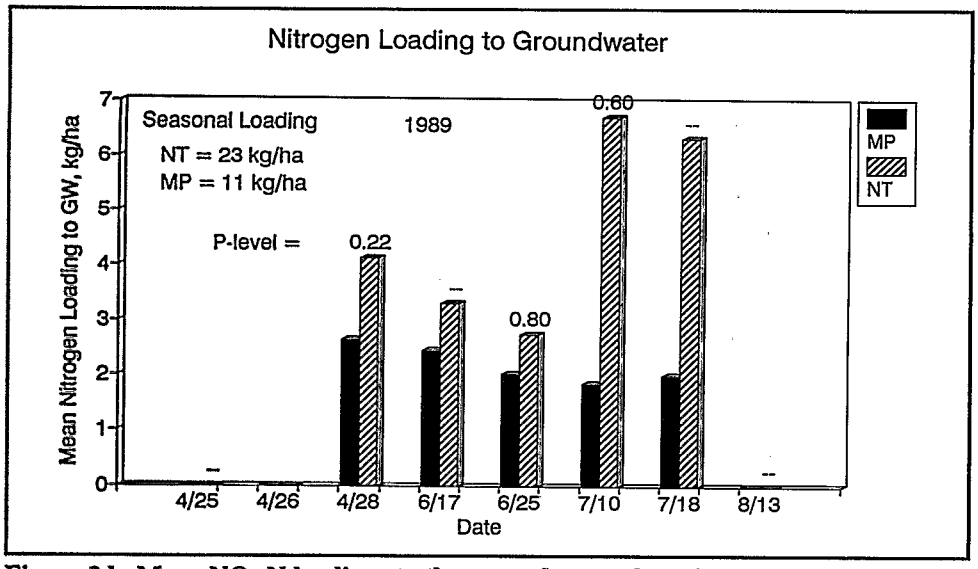

Figure 3d. Mean NO_3-N loadings to the ground water from individual rainfall events (calculated from Figures 3b and 3c).

of these cases. Ground water loading may be significant in the most severe instance, i.e., when surface-applied chemicals are used and a storm with a high intensity causes significant runoff shortly after application. Wauchope (1978) found in his review that surface runoff pesticide losses are usually the greatest for the first runoff event after application. The implementation of BMPs may help to hold more of the rainwater on the area where it falls and reduce the potential impacts from off-site runoff.

Pesticides in the Vadose Zone

In monitoring the vadose zone for pesticides for 2 years, there was a slightly higher number of detections of pesticide per water sample collected on the moldboard plow treatment compared to the no-tillage treatment for the upper 1.8 meters of soil for each of the 2 years (Figures 4a and 4b). The pesticide detection rate follows the same pattern as the NO_3-N concentrations in the vadose zone—decreasing number/concentration with increasing depth below ground surface. The water samples that were collected from below the water table at the 4.5 meter depth showed the reverse—the no-tillage treatment has a higher number of detections per sample collected than the moldboard plow tillage treatment. This may be attributable to the fact that more pesticides are held higher in the soil profile (thus, more detections) for the moldboard plow system compared to the no-tillage system. This would parallel the results associated with the nitrate concentrations between the two tillage systems. It should be emphasized that the differences that are shown in pesticide detection between the tillage systems are not significant at the 0.05 level of probability.

In evaluating the number of pesticides detected from unsaturated water samples taken at different levels below the ground surface, all indications point to decreasing detection per sample collected as the depth increases. The detection level of the ten pesticides analyzed were quite different, but were lumped into the same database for analysis. Trifluralin (Treflan), terbufos (Counter), and fonofos (Dyfonate) had detection limits of 10 nanograms per liter (ng/l) and almost 50 percent of the pesticide detection in the unsaturated zone were from these three pesticides, when only one of these pesticides (terbufos) was applied.

Watershed Planning for Pesticide Control

Precipitation patterns and other climatic factors affect the potential for runoff and infiltration to a specific site. If there is higher seasonal precipitation between years, there is probably more runoff and more infiltration into the soil profile and, possibly, more leaching toward the ground water. The potential for leaching of a pesticide to the ground water is a function of: (1) the method of pesticide application, (2) the time between application and the first precipitation event, (3) tillage practice and surface residue, (4) crop and stage of growth, (5) pesticide properties, and (6) soil organic matter. In agricultural watersheds where pesticides are used regularly, the most volatile time for movement of pesticides to either surface or ground water occurs immediately after application. As time increases after application, the dissipation, volatilization, and adsorption mechanisms are developed, and movement with rainfall

tends to decrease. With increased adoption of conservation tillage practices, there is also an increased need to more efficiently apply herbicides to reduce losses to waterbodies. The engineering profession is challenged to develop new methods of application, yet still maintain effectiveness of the applied herbicide. One mechanism that may help would be to place the herbicide slightly below the soil surface. With increased residue on the soil surface, this becomes increasingly more difficult. The present question of whether there should be more, or less, conservation tillage practices implemented in the watershed to protect water quality comes down to which waterbody is more important to protect. Second, the subsurface geology is evaluated to determine the potential for significant drinking water contamination in the ground water. When both surface and ground water are of equal priority, all indications are that the benefits of increased implementation of conservation tillage practices to reduce surface erosion and runoff losses exceed the potential detriment to the ground water through increased leaching (Baker, 1992).

Although protection of ground water for drinking water purposes from nonpoint source agricultural contamination is less expensive than any clean-up effort may be, it should be emphasized that the "jury is still out" relative to the potential for degradation of most pesticides already present in ground water. Subsequently, it should not be construed that the mere presence of a pesticide in ground water implies that the process of reducing the contaminant is either an irreversible or economically reversible process. There may be mechanisms and/or processes that degrade the contaminant(s) in shallow ground water systems that have not yet been established in the literature.

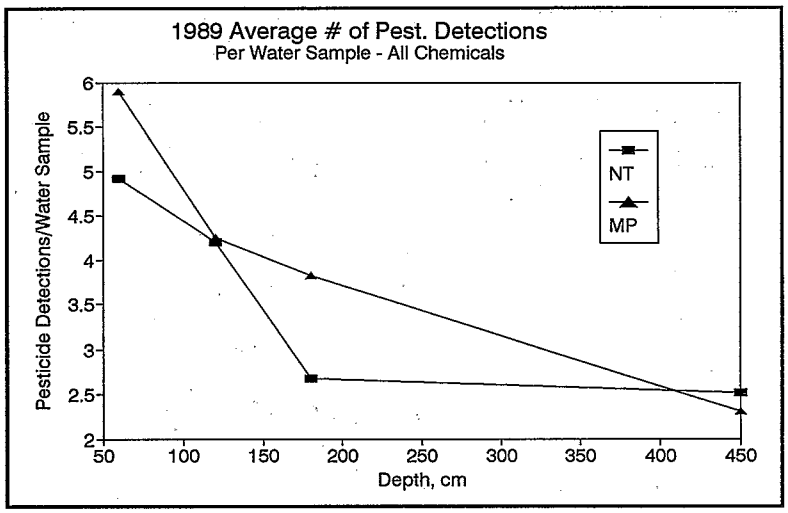

Figure 4a. The average number of pesticide detections per water sample collected from the vadose zone study for two tillage treatments for 1989. (Ten different pesticides analyzed; total samples collected were from 23 to 166; 5 leaching/rainfall events)

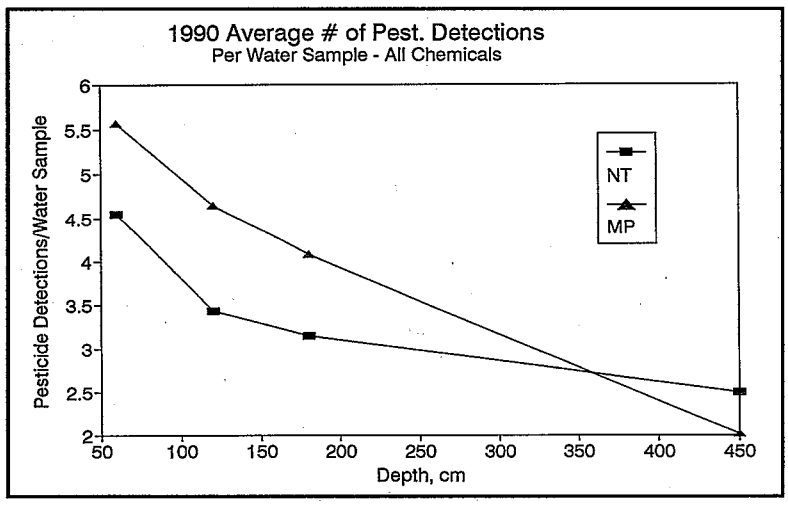

Figure 4b. The average number of pesticide detections per water sample collected from the vadose zone study for two tillage treatments for 1990. (Ten different pesticides analyzed; total samples were from 28 to 189; 16 leaching/rainfall events)

Summary

Watershed planning for nonpoint source agrichemical contamination of surface and ground water is a complex issue. Planning to protect all waterbodies for all events and situations all the time may not be possible. In planning for the protection of water resources within the watershed the key resources need to be prioritized. The presence of a pesticide in shallow ground water should not be thought of as an irreversible process. The research community will continue to determine methods of agrichemical management to minimize the potential for movement into both ground water and surface water. Commercial agrichemical producers will develop alternatives for problem pesticides in the environment, as more emphasis is placed on the environment by the public.

Factors that need to be considered for long-term agricultural watershed planning are:

- Prioritize the resource. Determine which is the more important re-

source—the surface or ground water, or both; (e.g., shallow ground water in glacial till soils may be less important than ground water in outwash soils).

- Plan for long-term climatic patterns based on historical records. Particular attention should be paid to early spring rainfall patterns, intensities, and the percentage of time that rain falls in these vulnerable time frames. If this information is not available, it should be processed from raw data.
- Gather detailed information about the subsurface geology within the watershed.
- Determine site-specific interactions between ground water and surface water.
- Determine average seasonal ground water flow direction and approximate velocity.
- Consider run-on potential and off-site up-gradient land use when applying BMP's for the protection of ground water.
- Determine strategies for implementation of fertilizer and pesticide management or conservation tillage. Management over shallow aquifers may be different from areas not over aquifers.

The use of watersheds to evaluate the impact of agricultural management on loading of agrichemicals and runoff water is expensive, but of value, and there are parameters that can be determined from watersheds that cannot be obtained by site-specific field monitoring, plot studies, or laboratory studies. This is not to de-emphasize the importance of these methodologies to determine the micro-environment.

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Measuring the Drinking Water Impacts from Two Agricultural Watershed Management Programs in the Midwest

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The benefits of pesticides and herbicides are well-known. They have done much to reduce the ravages of disease, crop infestation, noxious animals, and unwanted weeds. Approximately 1.1 billion pounds of pesticides and herbicides are produced with a total production value of about $5 billion. Approximately 77 percent of the production is used in agriculture; 16 percent in industry, commerce, and government; and 7 percent in home and garden activities. However, some of the more commonly used herbicides could pose a potential compliance problem for water utilities.

The 1986 amendments to the Safe Drinking Water Act (SDWA) directed the U.S. Environmental Protection Agency (EPA) to develop national drinking water standards for a list of 83 compounds. EPA was directed to develop Maximum Contaminant Level Goals (MCLGs) and Maximum Contaminant Levels (MCLs) for each of these 83 compounds. In this list are several of the more commonly used herbicides, including atrazine and alachlor. MCLs for atrazine and alachlor became effective on July 1, 1992. The standardized monitoring framework for all the regulations began January 1, 1993. Once the standardized monitoring begins for the more commonly used herbicides, surface water supplies in the Midwest could face a potential compliance problem with the MCLs for these herbicides.

Watershed management is an alternative to installing additional treatment for utilities with potential compliance problems from these herbicides. For watersheds dominated by agriculture, the use of best management practices, such as buffer strips and grassed waterways, can have a significant impact on the concentrations of herbicides in the drinking water supply. The effectiveness of best management practices in two agricultural watersheds will be evaluated by examining the concentrations of the herbicides in the drinking water reservoirs in the two watersheds.

SDWA Regulations

Since the 1986 SDWA amendments, EPA has been in a crash program of regulatory development for drinking water. Final MCLs for 22 pesticides and herbicides have been established in both the Phase II and Phase V regulations. The Phase II regulation established MCLs for 13 pesticides and herbicides. These MCLs became effective on July 1, 1992. The Phase V regulation established MCLs for nine pesticides and herbicides. These MCLs become effective on January 17, 1994. The standardized monitoring framework, including the Phase II regulations, began January 1, 1993. However, the monitoring for the Phase V regulations began January 1, 1993, for only the large systems, serving a population of greater than 10,000. Monitoring for the Phase V regulations for the medium and small systems does not begin until January 1, 1996. Table 1 lists the

Table 1. MCLGs and MCLs for pesticides and herbicides in Phase II and Phase V regulations

Pesticide	MCLG(mg/l)	MCL(mg/l)
Phase II Regulation		
Alachlor	Zero	0.002
Atrazine	0.003	0.003
Carbofuran	0.04	0.04
Chlordane	Zero	0.002
1,2-Dibromo-3-Chloropropane (DBCP)	Zero	0.0002
2,4-D	0.07	0.07
Ethylene Dibromide (EDB)	Zero	0.00005
Heptachlor	Zero	0.0004
Heptachlor Epoxide	Zero	0.0002
Lindane	0.0002	0.0002
Methoxychlor	0.04	0.04
Toxaphene	Zero	0.003
2,4,5-TP (Silvex)	0.05	0.05
NOTE: The MCLGs and MCLs for aldicarb, aldicarb sulfone, and aldicarb sulfoxide have been stayed indefinitely, pending review of new toxicological data		
Phase V Regulation		
Dalapon	0.2	0.2
Dinoseb	0.007	0.007
Diquat	0.02	0.02
Endothall	0.1	0.1
Endrin	0.002	0.002
Glyphosate	0.7	0.7
Oxamyl (Vydate)	0.2	0.2
Picloram	0.5	0.5
Simazine	0.004	0.004

pesticides and herbicides in the Phase II and Phase V regulations, and their respective MCLs and MCLGs.

The pesticides and herbicides listed in Table 1 are monitored for compliance on a quarterly basis, using a specific analytical method developed by EPA. Compliance with the MCL is based on a running average on four quarterly samples. If a utility violates the MCL, then the public has to be notified, and additional treatment must be installed to bring the utility back into compliance.

The author believes that utilities using surface water as their source will have a greater potential for compliance problems than systems using ground water as their source. Certain pesticides and herbicides, such as aldicarb, can leach into ground water and create compliance problems. While the potential compliance problems for ground water should not be ignored, recent monitoring studies show that surface water may be a larger problem. Sixty-seven percent of the population of the United States served by community water systems use surface water as their source. Two scenarios could create potential compliance problems for utilities using surface water as their raw water source. First, the effect of the spring flush on rivers and streams could provide a volume of reservoir inflow with a high concentration of pesticides and/or herbicides. Even with mixing in the reservoir, this mixing could create a single sample at a concentration of four times the MCL. Based on a running annual average of four quarterly samples, even with no detections of pesticides and/or herbicides in the other three quarterly samples, one sample at four times the MCL would be an MCL violation. Second, reservoirs and lakes with a watershed dominated by agriculture can accumulate levels above an MCL on a year-round basis.

West Lake

West Lake is the surface water reservoir for the cities of Osceola and Woodburn, in south-central Iowa. The lake covers 306 surface acres at normal pool, and has a 6,350 acre drainage area. Cropland, primarily in corn-soybean rotation, occupies 4,188 acres (approximately 2/3) of the watershed.

EPA sampling of West Lake in 1987 detected levels of atrazine and cyanazine above the federal drinking water standards Extensive sampling in 1991 confirmed continued high concentrations of atrazine and cyanazine in West Lake. Pilot testing was conducted in 1991 using Powdered Activated Carbon (PAC) to adsorb the herbicides to maintain compliance. As an alternative to the PAC treatment, a watershed management plan was developed by the Clarke Soil and Water Conservation District.

The goal of the 5-year watershed management plan is to lower the concentrations of atrazine and cyanazine in West Lake. Twenty-five hundred acres with 41 landowners were targeted for farmer incentives, including financial payment for acres contracted into undertaking soil conserving practices, soil fertility analysis, sprayer calibration; evaluation of land use; assistance in implementing reduced or no-till

systems; and fertility and crop pest consultation.

Due to continual high levels of atrazine or cyanazine in West Lake in 1991, 90 percent of the farmers in the watershed agreed to reduce or eliminate their use. This agreement resulted in only 15 percent of the farmers using a product that contained atrazine and cyanazine in 1992 compared to almost 100 percent in 1991. Figures 1 and 2, which indicate the concentrations of atrazine and cyanazine in 1991 and 1992, show the results of these agreements. Atrazine and cyanazine levels in West Lake dropped substantially in 1992. Average atrazine levels in 1992 were below the MCL of 3 parts per billion (ppb), and average cyanazine levels in 1992 were closer to the new lifetime Health Advisory Level of 1 ppb.

Perry Lake

Perry Lake is a reservoir on the Delaware River in northeastern Kansas. The reservoir is used as raw water supply for several rural water districts and for state parks that border the reservoir. EPA sampling in 1991 detected atrazine levels above the MCL of 3 ppb. On the basis of that sampling, the Kansas State Board of Agriculture established a Pesticide Management Area (PMA) for atrazine within four watershed districts: Delaware, Nemaha Brown, Little Delaware Mission Creek, and Thompsonville. The establishment of this PMA generated intensive controversy within the agricultural community. The pesticide management plan include management and conservation practices, education, monitoring, research, enforcement, and evaluation.

The voluntary management and conservation practices include limitations of the atrazine application rate, the use of a 33-foot stream buffer zone, and promotion of integrated pest management and alternative weed control. An intensive educational and outreach program has been developed, along with an intensive monitoring program to evaluate the effectiveness of the PMA.

As shown in Figure 3, which indicates the atrazine concentrations at three locations in Perry Lake, the effectiveness of the PMA is difficult to evaluate after only one year of implementation. The atrazine levels in Perry Lake have fluctuated above and below the MCL of 3 ppb. Additionally, the rainfall in May and June of 1992 was below average, and the impact of the below-average rainfall is difficult to quantify. Several years of monitoring will need to be conducted in order to evaluate the long-term effectiveness of the PMA.

Conclusions

The use of herbicides can have a significant impact on drinking water utilities using surface water. These utilities can face potential compliance problems with the MCLs established for the herbicides and may have to install additional treatment in order to maintain compliance. Watershed management is a promising alternative to the additional treatment.

The watershed management program for West Lake has been successful due to the

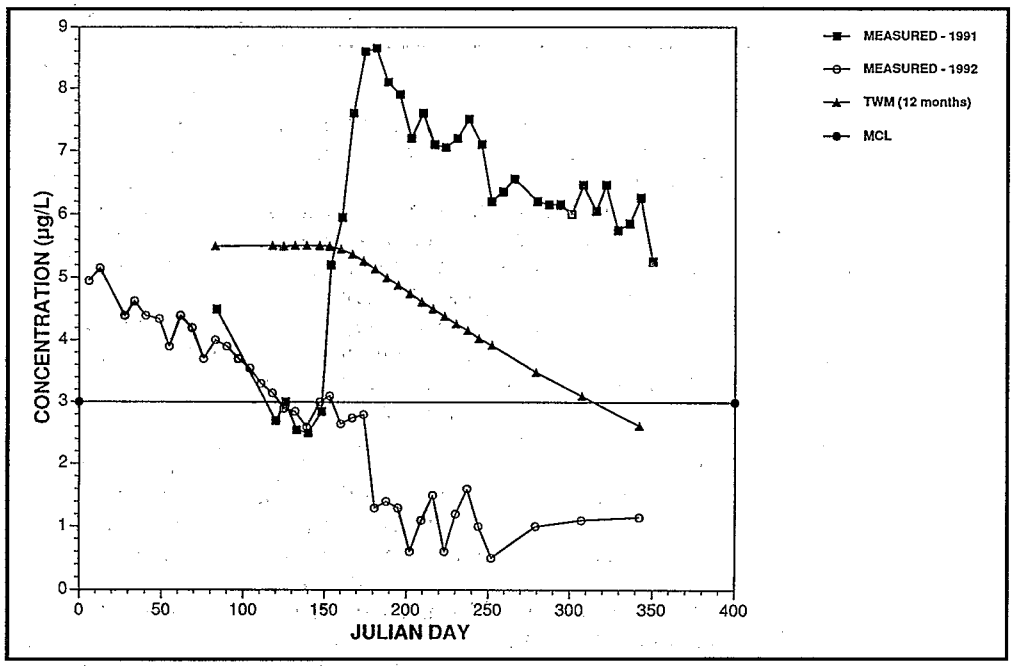

Figure 1. Atrazine in finished water (1991 and 1992).

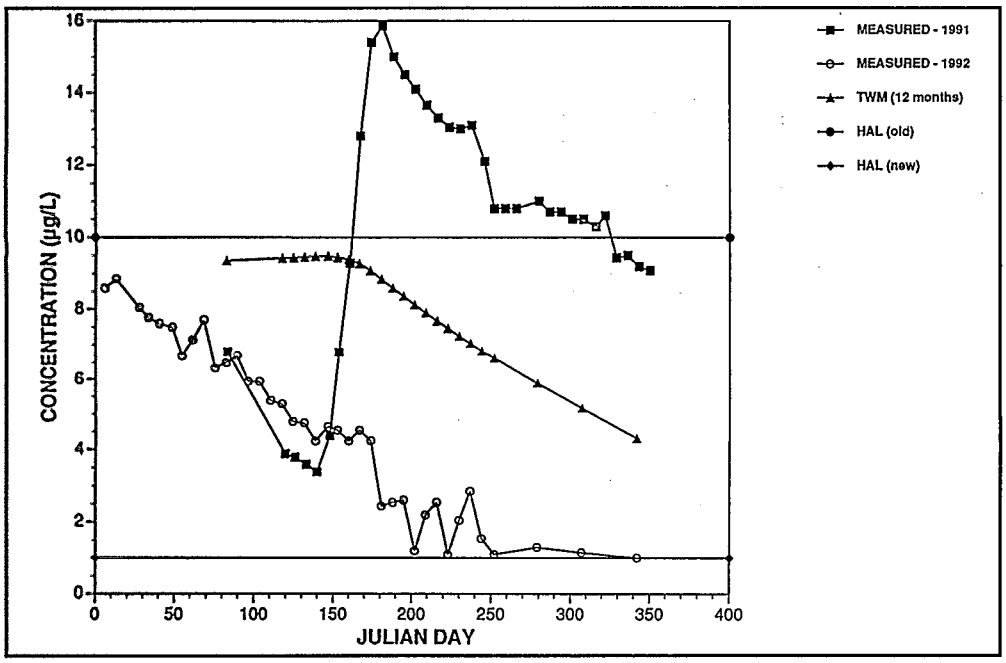

Figure 2. Cyanazine in finished water (1991 and 1992).

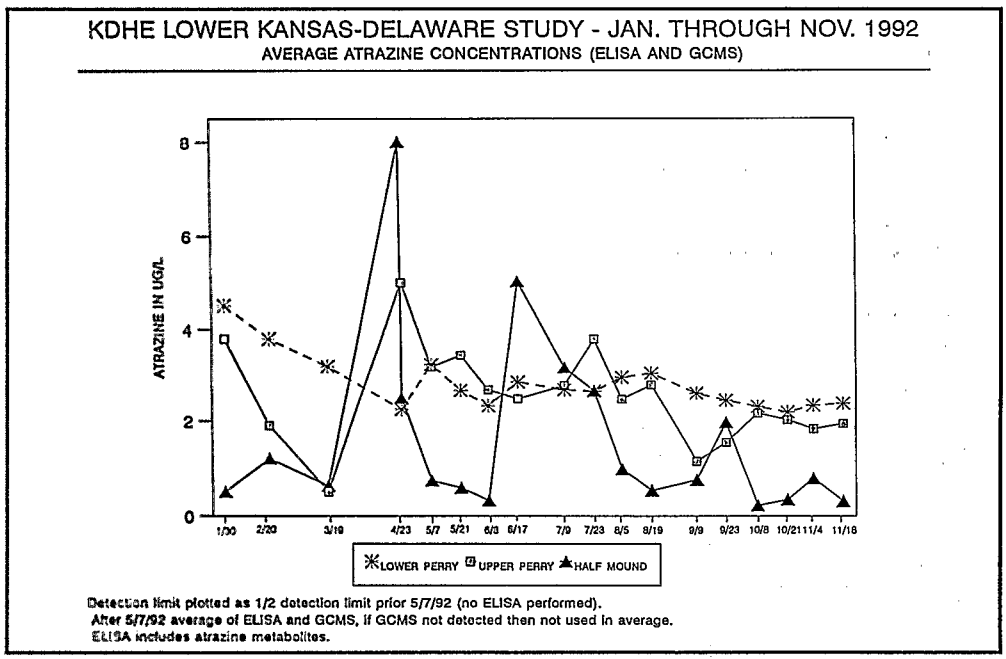

Figure 3. Lake Perry atrazine concentrations.

high percentage of farmers participating in the voluntary program. Herbicide levels in the reservoir have been substantially reduced. The limited number of landowners and relatively small size of the watershed contributed to the success of this program.

The watershed management program for Perry Lake is more difficult to evaluate. The larger number of landowners and the large watershed area make the impact of the program difficult to assess, especially after only 1 year of monitoring. Additional monitoring over a longer time period will be needed to evaluate the effectiveness of this program. This program also illustrates the impact of variations in rainfall. A drier than average year could make a program seem more effective than it actually is. Interpretation of the monitoring data needs to account for the variation in rainfall.

Assessing Ground Water Contributions to Pollutant Loadings to the Middle Fork of the Snake River, Idaho

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Purpose

The purpose of this paper is to assess the role of ground water in sustaining adequate quantity and quality of flows to the Middle Fork of the Snake River in Idaho and to relate the significance of these findings to existing watershed management alternatives. Over the past 5 years, intense algal and macrophyte blooms have occurred along the river near Twin Falls, ID. This eutrophication limits beneficial uses of the river, including recreational uses and salmon spawning, and has impeded issuances of National Pollutant Discharge Elimination System (NPDES) permits and Water Quality certifications. Nutrient loading from both point and nonpoint sources, combined with low river flows are creating one of the region's worst water pollution problems.

Several agencies are addressing this problem of eutrophication, including the Idaho Department of Environmental Quality (IDEQ), Region 10 of the U.S. Environmental Protection Agency (EPA), the U.S. Geological Survey (USGS), and the University of Idaho. To date, however, their management plans and research activities have largely treated surface water resources separately from ground-water resources and have not explicitly investigated the effects of ground-water quantity and quality on river water quality.

Study Area

The study area is composed of the northern part of the eastern Snake River Plain, south to the Snake River, from Twin Falls to King Hill. This stretch of the river is commonly known as the "1000 Springs" reach since it contains 11 of the 65 largest springs in the United States, as well as innumerable and unnamed smaller springs (Covington et al., series).

The eastern Snake River Plain aquifer is 10,800 square miles in area and is composed of thick sequences of thinly layered Quaternary basalt flows. The interflow zones are characterized by intensely fractured vesicular basalt and cinders. Horizontal ground-water flow through these interflow zones is several orders of magnitude greater than is flow through the rest of the basalt, and transmissivity values of 100,000 feet squared per day are common. On a regional basis, the eastern plain aquifer acts as an unconfined aquifer (Whitehead, 1992).

Conceptual Model of Land Use Effects on Ground-Water Discharge to the Snake River

Existing data on land uses on the eastern Snake River plain were reviewed and synthesized to develop a conceptual model of how land uses and water resource

development affect the quality and quantity of Snake River flows. Six types of land uses are considered: irrigated agriculture, underground injection of irrigation tailwater, animal feedlots, aquaculture, septic systems, and land application of wastewater. The effects of each of these activities on the Snake River were estimated in terms of:

1. The magnitude of the activity's effect on water *quantity.*
2. The magnitude of the activity's effect on water *quality.*
3. The *immediacy* of the effect on water quantity.
4. The *immediacy* of the effect on water quality.
5. How widespread the activity is, in terms of spatial distribution across the Snake River plain.

This assessment is summarized in Table 1, along with a qualitative ranking of the priority that the activity should receive for management action or for targeted, applied research to verify the estimated effects. As shown in Table 1, three activities received high-priority rankings. These are irrigated agriculture, feedlots and dairies, and aquaculture. Each of the lower priority activities may contribute nitrate to ground water. Their aggregate effects, however, on the quality and quantity of Snake River flows were estimated to be far less. For example, septic systems and land application of wastewater were each estimated to contribute about 0.003 million acre feet to recharge of the regional aquifer, or fully three orders of magnitude less than recharge from irrigated agriculture. Similarly, it is clear that injection of irrigation tailwater into numerous "drain" wells completed in basalt fracture patterns or into shallow wells dug by backhoes can directly contaminate ground water, despite the fact that existing data cannot support estimates of quality or quantity effects to the river. Nonetheless, this activity received a "moderate" priority ranking because other factors are decreasing the amount of tailwater requiring disposal. These factors include the continuing trend toward replacement of gravity irrigation systems by more water-efficient center pivot and sprinkler irrigation systems and the increasing efforts to educate farmers to irrigate in amounts established on agronomic water need data for specific crops.

Results for Irrigated Agriculture

Water development for irrigated agriculture is the single dominant use of water on the Snake River plain. Water budgets show that more than 60 percent of the total annual recharge—or about 5.1 million acre-feet for the 1980 water year—is returned to the aquifer system through

Table 1. Summary of the effect of watershed activities on the quantity and quality of ground water discharging to the Mid-Snake River

	Water Quantity		Water Quality			
Stressor	Potential Magnitude of Impact	Immediacy or Effect	Potential Magnitude of Impact	Immediacy of Effect	Existing Spatial Distribution of Activitiy	Priority for Further Action
Irrigated agriculture	High	Rapid	High	Slow	Widespread	High-Targeted Research
Underground injection of irrigation tailwater	Low-moderate	Moderate	Low-moderate	Rapid	Localized	Moderate
Feedlots and dairies	Moderate	Unknown	High	Slow	Localized	High-Targeted Research
Land application of wastewater	Low	Moderate	Low	Slow	Localized	Low
Septic systems	Low	Moderate	Moderate	Slow	Localized	Low-Moderate
Aquaculture	Low	N/A	High	High	Locallized	High-Targeted Research

infiltration, return drains, and canal seepage (Hughes, 1991). Similarly, USGS has estimated that if there were no irrigation development within the entire Snake River Plain, the average annual flow in the Snake River would be 4 million acre-feet greater at King Hill, and 6 million acre-feet greater at Weiser, located about 205 miles further down river (Kjelstrom, 1986).

Moreover, changes in agricultural practices have been correlated to changes in the quantity of flows to the Snake River. In 1910, prior to extensive water development within the basin, ground-water discharge to the 1000 Springs reach of the river was approximately 4,300 cubic feet per second (cfs). By the late 1940s, approximately 2.5 million acres were being irrigated on the plain, largely by water-inefficient, gravity-fed irrigation systems which return 25 to 50 percent of the irrigation water to the aquifer system via infiltration (Lindholm and Goodell, 1986). By the mid-1950s, ground-water discharge from this reach increased to about 6,800 cfs (Hughes, 1991).

About 1945, irrigators began to pump ground water to supplement surface water supplies, thus removing water from aquifer storage. Irrigation canals were lined to conserve water, concomitantly decreasing recharge to the aquifer. Ground-water discharge along the 1000 Springs reach began declining in 1956 and reached a low of about 6,200 cfs in 1964 (Kjelstrom, 1986). As a result of increased use of more water-efficient center pivot and sprinkler irrigation systems during the 1980s, ground-water discharge continued to decline to about 5,500 cfs in 1991 (Hughes, 1991).

It is clear that irrigated agriculture has a major effect on the quantity of water available to the 1000 Springs stretch of the Snake River and that these quantity effects are evident within a only a few years. With irrigated agriculture widespread and upgradient of the localized ground-water discharge to the Snake River, it is qualitatively evident that irrigation has high potential for nitrate loading. There is, however, scant nitrate data for ground water to quantify estimates of nitrate loading due to agriculture (Yee and Souza, 1987).

The best available information on nitrate loading potential comes from two relatively small-scale studies of irrigation districts. In one district, located about 5 miles east and upgradient of the central study area, 24 wells were sampled for nitrate within about a 125 square mile area. Nitrate levels varied from about 3.8 to 336.7 milligrams per liter (mg/l) as dissolved nitrate, with a median value of 41.2 mg/l. Thirteen of the 24 samples had dissolved nitrate nitrogen values greater than 38.9 mg/l, and these concentrations were collected from water table depths of from 16 to 97 feet below the land surface (Young et al., 1987). While the second district is not located within the study area, the data corroborate the high potential for nitrate loading from irrigated agriculture. The nitrate values from 76 wells varied from 1.6 mg/l as dissolved nitrate nitrogen to 132.9 mg/l, with a median value of 35.4 mg/l. Twenty-five percent (19 of 76) of the wells sampled yielded dissolved nitrate nitrogen values of greater that 44.3 mg/l. Depth to water for these wells varied from 6 to 216 feet below land surface (Young et al., 1987).

Thus, irrigated agriculture has significant potential to contribute nitrate to the Snake River and to also affect the timing and quantity of stream flows. It is important, however, to distinguish between the timing of these effects. Previous studies have shown that changes in pressure head, and thus ground-water discharge, occur rapidly with recharge quantities of this magnitude. In contrast, studies at two springs along the 1000 Springs reach suggest there may be up to a 40-year lag before changes in the chemical quality of spring flow will be evident (Wood and Low, 1988). In addition, the pattern of agriculture on the plain has been relatively constant since about the 1950s; thus the distribution of agricultural nutrients is likely to be in a comparatively steady-state condition (W. Low, USGS, personal communication). These conditions suggest an expected lag of several years before the beneficial effects of improved agricultural practices would be evident in the in-stream flows of the Snake River.

Results for Dairies and Feedlots

The U.S. Department of Agriculture estimates that there are 600 feedlots and dairies containing about 270,000 head of cattle within just 4 counties in the study area (USEPA, n.d.). An additional 100,000 to 150,000 head of dairy cattle are

anticipated within the next several years to support a new cheese plant in Jerome. Currently, potential discharges to ground water from animal feedlots are not addressed by any permit mechanism. The volume of water and wasteloads from existing feedlots were estimated to be from 0.23 to 0.41 million acre-feet/year. This volume is roughly a factor of 2 times greater than the combined wasteload from the entire human population of Idaho and is the second highest loading rate estimated for the six land uses.

There is insufficient existing data on water quality in the Snake River mainstem down gradient of the major feedlot areas to assess feedlots as source areas for water quality impacts. Data from one sampling station near Buhl, however, showed average colony values of 71/100 milliliters and 173/milliliter for fecal coliform and streptococci fecal, respectively (Harenberg et al., 1991). Existing data did not permit assessment of how rapidly river water quality could be affected. Overall, the potential water quantity effect was rated as moderate and the potential water quality effect was rated as high.

Results for Aquaculture

The IDEQ estimates that as much as 80 percent of the spring flow along the 1000 Springs reach is used by fish hatcheries. The hatcheries collect the springflow in flumes and use it as a water source for fish ponds. Although existing data did not permit an assessment of total discharge from hatcheries, a gaged estimate for a single hatchery was 19,200 acre feet in one year (Harenberg et al., 1988). There are 124 fish hatcheries on the mainstem and tributaries to the Snake River within the study area (USEPA, n.d.). Aggregate effluent volume is likely to be second only to ground-water discharge volume for irrigated agriculture. Unlike agriculture, however, aquaculture has the potential only for altering the quality of the springflow to the Snake River, not for changing the quantity of discharge. That is, the aquaculture industry is making temporary use of what would otherwise be direct springflow to the river and perhaps altering its quality in the process.

Aquaculture effluent is covered under NPDES permits for 85 of these hatcheries. New hatcheries or expansions to existing hatcheries will not be certified unless the facility can demonstrate that the new or additional effluent will not produce a net increase in nutrients. Brockway (1992) conducted a 12-month study of nutrient loading from aquaculture to the middle fork of the Snake River. His data showed effluent concentrations of nitrate nitrogen that varied from 1.3 to 9.9 mg/l. A separate, unpublished study by MacMillan (1992) concluded that there was no significant increase in nitrate nitrogen between the hatchery effluent and influent. Additional studies of the quality of hatchery effluent are scarce. Aerial photography, however, shows elongated algal blooms emanating from where the effluent enters the river, suggesting the hatcheries as a source of nutrient enrichment (M. Rupert, USGS, ID, personal communication).

Conclusions

This preliminary analysis suggests that irrigated agriculture, animal feedlots, and aquaculture have the potential to contribute, via ground-water discharges, significant nitrate loadings to the middle fork of the Snake River. This potential ground-water link to surface water quality and quantity has been little studied; further research is warranted to verify or refute these estimated effects. Ideally, the structure of such research would be designed to dovetail with the efforts of long-term, field-based studies planned by several agencies, such as the USGS's National Water Quality Assessment study for the area or the Nutrient Management Plan being developed by EPA's Region X, IDEQ, and the Water Resources Institute at the University of Idaho. The analysis begun in this study could be substantially refined and nutrient loading estimates locally disaggregated if existing data were pooled for collaborative interpretation. In this way, progress toward developing nutrient loading estimates and water budgets could rapidly proceed on the basis of informed estimates, while incorporating these estimates into an iterative, ongoing process for refinement as data become available.

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The C-51 Basin: Evolution of a Single-Purpose Project to Achieve Multipurpose Water Resource Objectives in a Changing Public Policy Arena

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The southern half of Florida possesses a unique subtropical, water-based ecosystem. This large natural system begins with a chain of lakes south of Orlando that feeds the Kissimmee River, which flows into Lake Okeechobee—the second-largest freshwater lake in the Nation. The lake in turn is the source of water for that famous "river of grass," the Everglades, which historically covered most of the territory to the south and still feeds Florida Bay at the tip of the peninsula. (See Figure 1.)

That is the big picture for this incredible ecosystem which man has subdivided into many compartmentalized basins. In fact, the history of development in South Florida for more than 100 years is one of "dredge and drain the swamp" to create dry land out of wet land. The South Florida Water Management District, an agency created to manage the region's water resources, faces a huge challenge to bring together the appropriate federal and state agencies and local stakeholders to restore those important links in this unique environmental corridor. Bruce Babbitt, Secretary of the Interior, recently said he wants restoration of the larger Everglades ecosystem to be a model of environmental restoration for the Nation, an indication of the Clinton administration's support for these efforts.

A related part of the overall effort to restore the Everglades is the water management district's recent initiative to develop a new, multiobjective design for an existing flood control canal and its adjacent basins. The objectives of this ambitious redesign include restoring the water flow to the northern end of the remnant Everglades, reestablishing the canal basin's natural link to a nationally prized coastal riverine system, and reducing harmful storm water discharges to downstream estuaries.

In addition to these vital features to enhance the basin's environment, this new design proposal will be an important element in the water management district's "water supply planning" process, while still accomplishing the flood protection improvements that were the basis of the original project. This project, once considered a threat to the northern Everglades, now will provide benefits for Everglades restoration. The remarkable evolution of this one-time flood control project will be a model for future agency projects and serve as proof of Florida's commitment to save the Everglades.

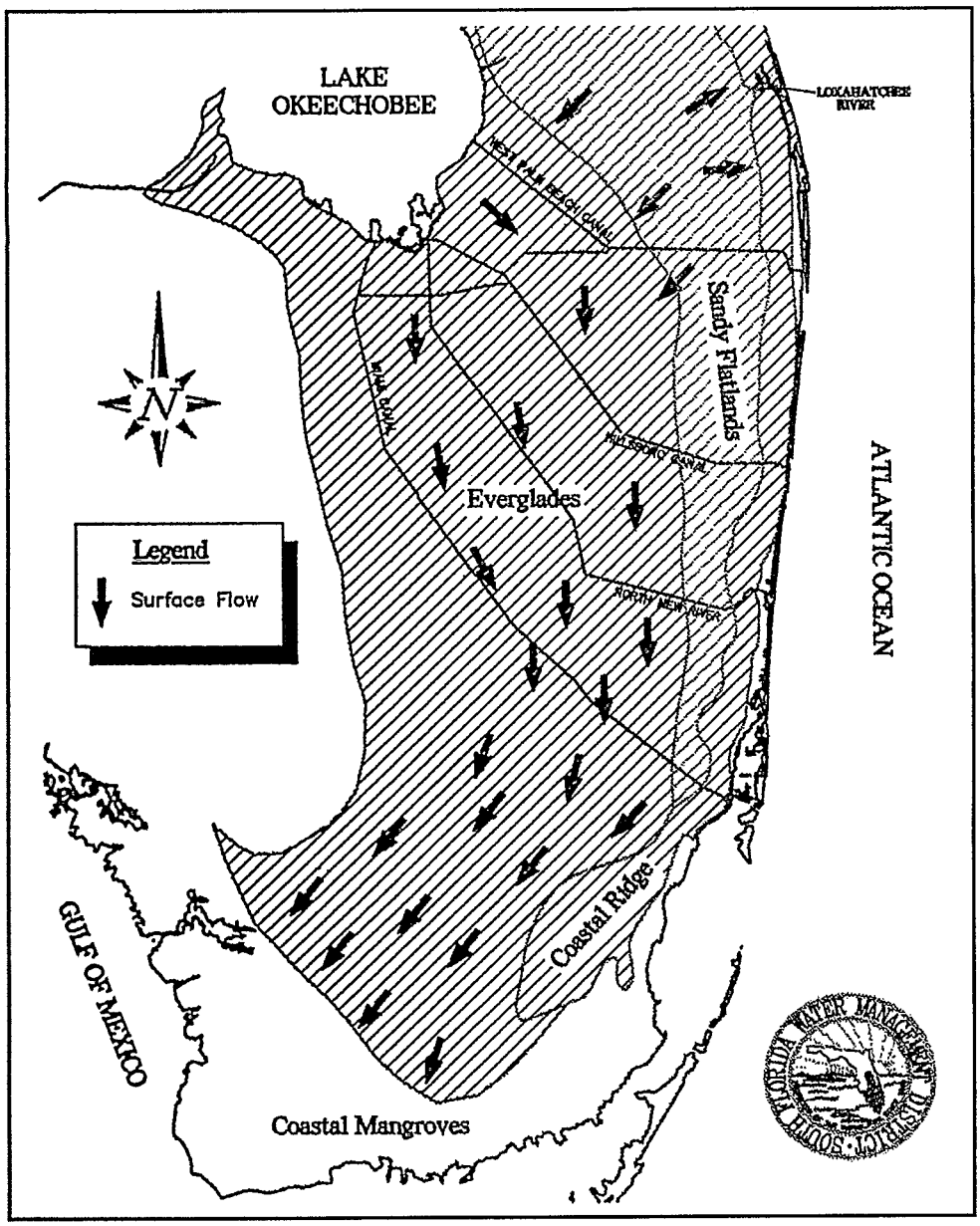

Figure 1. Ecologic map of southern Florida.

The State of Florida originally constructed this canal more than 70 years ago in east central Palm Beach County to link agricultural lands on the south side of Lake Okeechobee with seaports along the east coast. The old Everglades Drainage District christened this man-made channel the West Palm Beach Canal. It has been called the C-51 canal since becoming part of the federal Central and Southern Florida Flood Control Project. The South Florida Water Management District is local sponsor for this project—one of the world's largest and most complex water control systems, consisting of 1,400 miles of canals and levees with 181 structures and 18 pumping stations. The District operates and maintains the project not only to accomplish its original flood control mission, but also to keep pace with the region's changing water demands, growth, development, and environmental needs in a 16-county region with more than 5 million people.

During the 1930s and until the hurricane of 1947, South Florida endured periods of prolonged droughts interspersed with years of above-normal rain. During the mid-1940s, water levels in regional aquifers dropped, allowing salt water from the ocean to creep into coastal wellfields. Then the '47 hurricane hit South Florida. Water levels from the resulting floods took months to recede. These weather extremes showed the need for an overall plan to balance the flood control and water supply requirements of the region. (As a side note, South Florida was fortunate that Hurricane Andrew, in 1992, was not a "wet" hurricane.)

In 1948, Congress authorized the Central and Southern Florida Flood Control Project. The next year, the State of Florida created the Central and Southern Florida Flood Control District to be the project's local sponsor. Many works in the federal project incorporated and improved on those of early drainage efforts, such as the Everglades Drainage District.

To expand on the flood control district's work, the Florida Legislature passed the 1972 Water Resources Act, which created water management districts throughout the state. The legislation charged all the districts to control and regulate the use of ground water and surface water supplies and required a comprehensive

state water use plan, emphasizing the need to plan for current and future water demands. It also emphasized the need for the districts to protect environmentally sensitive waters. Legislation in 1976 changed the name of the Central and Southern Florida Flood Control District to the South Florida Water Management District to reflect more accurately its new multiobjective mission of environmental protection and enhancement, water supply, flood protection, and water quality protection.

The Natural System of the C-51 Basin

Since the turn of the century, man's modifications to the topography and drainage patterns in the area of the C-51 basin—to accommodate extensive growth—have inextricably altered the natural environment of the basin. Remnant uplands and wetlands still remain in small areas in and around the C-51 basin, but the original hydrologic patterns that created those habitats are mostly gone. These man-made changes have compromised the viability of the remnant natural systems, and so they eventually may disappear, unless specific actions are taken to ensure their long-term viability.

A "watershed divide" separating the Everglades from the Loxahatchee Slough to the northeast is the dominant hydrologic feature that shaped the area's historic environment. The slough drains to the ocean through the Loxahatchee River. This divide lies along a broad sandy flatland ridge which slopes gently to the southeast from Indiantown in Martin County to Lake Park in Palm Beach County. Pine and palmettos dominated the ridge, interspersed with seasonally inundated wetland ponds that provided food and water for wildlife.

The northern reaches of the Everglades lie west of this divide. Deep organic soils of peat and muck with widespread deposits of calcareous marl characterize the Everglades region. Its flat topography, sloping slightly southwest, stayed wet throughout the year. This vast wet prairie supported sawgrass, sedges, and maidencane, with isolated tree islands that contained dahoon holly, bald cypress, sweet bay, red maple, willow, and other species.

Northeast of the Everglades, the Loxahatchee River system is another very important environmental feature near the C-51 basin. It is Florida's only federally designated "Wild and Scenic River." The District hopes its work to reconfigure part of the C-51 basin will result in some "relinkage" of the two watersheds of the canal basin and the river.

Despite development in surrounding drainage basins, significant areas of the Loxahatchee River's floodplain and slough still remain in a natural state. However, diversion of rainfall runoff, because of nearby suburban growth, has reduced the river's base flow and altered its hydroperiod. The Loxahatchee Slough has a diverse wetland plant population, with cypress and broadleaf trees, and is vital habitat for alligators, osprey, endangered Florida panthers, and others.

The C-51 Canal and the Western Basin Project

When the federal government created the Central and Southern Florida Flood Control Project, plans included redesignating the eastern part of the old West Palm Beach Canal as the C-51 canal to control floods and supply water. (The C-51 now links two canals—the western part of the West Palm Beach canal and the L-8 canal from Lake Okeechobee through the northernmost Everglades to the Lake Worth estuary.) Agricultural and urban development in the lowlands of the western C-51 basin created demands for increased flood protection.

The U.S. Army Corps of Engineers (COE) completed its design of the entire C-51 canal project in 1972. Plans for this single-purpose project consisted of three major elements:

1. Replacing the coastal Palm Beach Locks with a modern water control structure, designated as S-155.
2. Constructing a major pumping station, S-319, at the west end of the C-51 canal to pump water into one of the federal project's water storage areas constructed in the northern Everglades (Water Conservation Area-1, which is managed as the Arthur R. Marshall Loxahatchee National Wildlife Refuge).
3. Constructing a "divide structure," S-155A, to separate the eastern and western C-51 basins.

The COE plan promised to provide flood protection for a "one-in-30-year"

rainfall event for the eastern C-51 basin and "one-in-10-year" storm protection for the western basin, and to capture excess water from the western basin to store in the Loxahatchee Refuge (or Water Conservation Area 1). In reality, the eastern basin receives flood protection for a "one-in-8- to 10-year" storm, while the western basin receives less than "5-year" protection.

Objections arose to such a massive undertaking so close to the northern Everglades. These included concerns about the quality of the storm water runoff discharged into an environmentally sensitive area (i.e., the Loxahatchee Refuge), the effects on the hydroperiod of the national wildlife refuge with the proposed annual discharge of up to 325,000 acre-feet of water into that area, and the creation of a "moral hazard." This "hazard" refers to the creation of a project built to relieve flood control problems that would then encourage overdevelopment in the basin and thereby create even greater flood control problems and needs. Because of these objections, COE shelved the western elements of the C-51 plan, but allowed the eastern segment, including the S-155 coastal structure, to proceed. Most storm water runoff from the C-51 basin flows through S-155 into Lake Worth.

After two severe storms in the C-51 basin in 1984, COE proposed modifying its 1972 plan to reduce the scope of the elements in the western portion of the project. The COE suggested a smaller pumping station, S-319, at the western end of the canal. This new pump station would have limited operational criteria that would reduce the proposed annual pumping of water into the Loxahatchee Refuge by 90 percent from the 1972 plan. The COE also established stringent planning and regulatory criteria for the western C-51 basin, which provided some assurances for water quality and growth management concerns. Still, environmental interests opposed the approval of such a project on the grounds that excessive amounts of poor-quality urban storm water from the east would be pumped west into the national wildlife refuge.

In 1988, after many public hearings and interagency meetings, COE proposed a plan to include a 1,600-acre storm water detention area at the western end of the C-51 project. The net effect of this proposed modification to the western C-51 project would have reduced the annual amount of water discharged into the refuge from 32,000 acre-feet (10 percent of the original 325,000 acre-feet) to less than 1,000 acre-feet. The COE predicted that the storm water detention area would have some filtering and cleansing effects on the runoff before it flowed into the refuge. This 1988 plan still did not satisfy members of the environmental community or the U.S. Fish and Wildlife Service, which manages the Loxahatchee National Wildlife Refuge.

The Future for the Western C-51 Project

In 1989, the Governing Board of the South Florida Water Management District approved a joint COE-District proposal for the western C-51 basin. This plan included enlarging the western 6 miles of the C-51 canal, building a 1,600-acre detention area to contain storm water runoff for a "one-in-10-year" storm, and constructing the necessary pumping stations and structures to operate the system. The proposed detention area was designed to reduce "backpumping" floodwaters into the Loxahatchee Refuge for rainfall amounts of less than the planned "10-year" design capacity of the western C-51 basin.

Following the Board vote, the District applied for the required permits from the Florida Department of Environmental Regulation. However, the District still needed to resolve the proposed discharge of lesser quality storm water to the Loxahatchee National Wildlife Refuge, which the Department of Environmental Regulation had designated as an "Outstanding Florida Water." (The department regulates Outstanding Florida Waters through a "nondegradation policy." These waters are designated for special protection because of their natural attributes.)

Between 1988 and 1991, South Florida endured yet another severe drought and water shortage. The District and other governmental entities realized the need to capture more storm water during the summer "rainy season" to use during the traditional winter and spring "dry season." Water demands always increase during the winter in South Florida because of the vast amount of agricultural production (sugar cane, tomatoes, lettuce, etc.) and seasonal population increases.

By this time, the District had begun its "water supply planning" process, which identified the "needs and sources" of the water supply for the entire lower east coast

of Florida (Palm Beach, Broward, Dade, and Monroe counties). Because of the need to make the best use of the region's freshwater supplies, the District reevaluated its historic flood control practices, the main objectives of which were to discharge the maximum amount of storm water to the ocean. The District is examining environmentally sound methods to store that water until it is needed for future use, which is one of the proposals of the western C-51 plan.

Recognizing the need to complete the western C-51 project as a multiobjective water resource initiative, the District's "Palm Beach County Water Supply Plan Advisory Committee" asked the agency to establish a subcommittee comprised of federal, state, and local officials and other interested parties who ultimately would become the beneficiaries of the comprehensive project. The District directed the "C-51 Design Review Group" to initiate the conceptual modifications for the western basin.

To address these new multiobjective issues, the District—under the leadership of Governing Board member Leah G. Schad, also chair of the Palm Beach County water committee—expanded the scope of the western C-51 basin project by incorporating water quality and supply as major features of the revised western C-51 plan. The District continues to include flood control benefits associated with the COE project to preserve the federal government's share of funding for the project.

The C-51 Design Review Group requested that the District provide the initial concept for the physical structures needed for proposed project. This work would incorporate the feasibility of a multipurpose project for the western C-51 basin beyond its original flood control mission. It also would provide the basis for the review and possible modifications of the plan by the design review group.

The District contracted with Burns & McDonnell, an architectural/engineering firm, to develop this initial design concept. Burns & McDonnell then developed two alternatives for the western C-51 project. Significant elements of those two plans include building a 14,025-acre reservoir system, making minimum modifications to the flood control plan, capturing and using the runoff from the western C-51 basin and adjacent L-8 basin, supplementing the water flow to the Loxahatchee Slough and River, and reducing storm water discharges to Lake Worth. These elements are not mutually exclusive for either plan. (See Figure 2.)

After reviewing the Burns & McDonnell plans, the C-51 Design Review Group requested that the District reevaluate several of the options for the proposed facilities—such as the structures, pump stations, and canals—that the group suggested during its review process. The District then selected Brown & Caldwell, a consulting firm, to develop additional

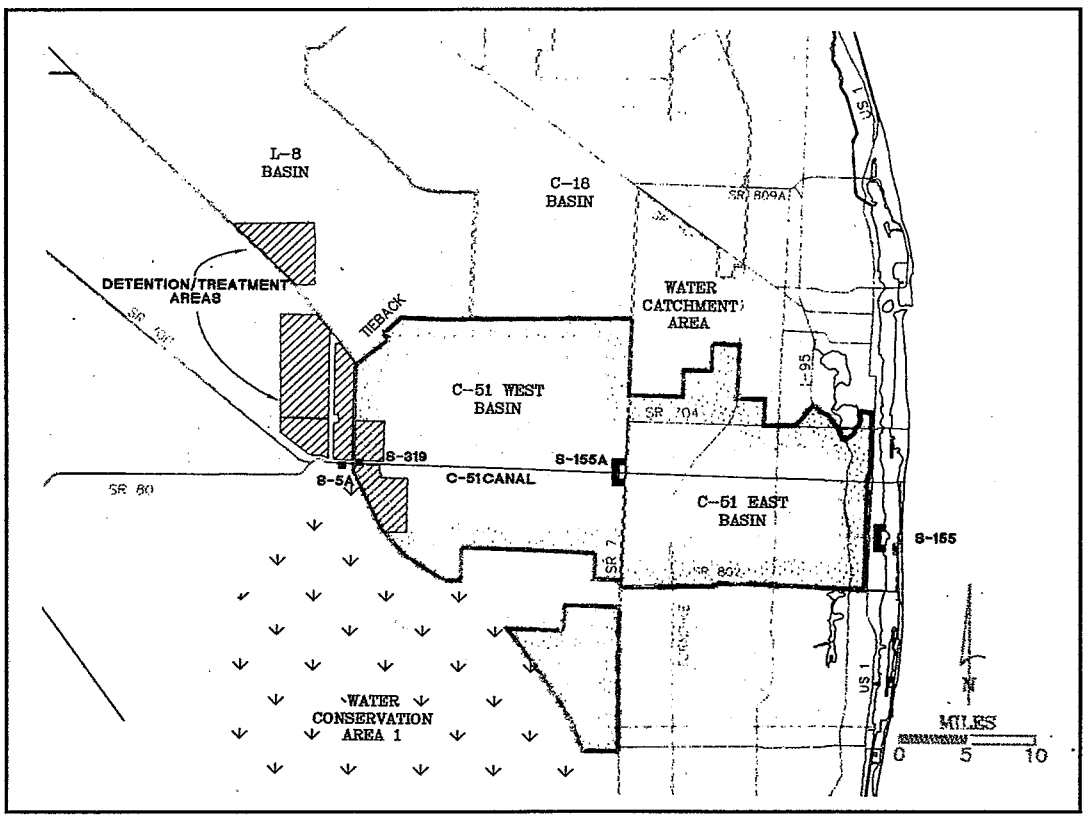

Figure 2. C-51 preliminary conceptual plan.

options and to prepare a more detailed analysis of the project with the assistance of the C-51 Design Review Group. This analysis would include the elements needed to develop these structural options and would evaluate the options based on environmental, water supply, engineering, and economic criteria. The final phase of the analysis would include selecting and ranking three alternative configurations for the western C-51 project.

After the Governing Board selects the best design option for the western C-51 basin, the agency then will incorporate that alternative into its Palm Beach County Water Supply Plan. The District's water supply plans ultimately will determine the water needs for all South Florida. These plans also will aid to increase the region's water supply, regulate water use to increase efficiency, and make the public aware of the water needs in this growing area.

The Effectiveness of Environmental Mediation in the Relicensing of Kingsley Dam and Keystone Diversion Dam

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The Platte's Predicament

The Platte River is a major hydrological system within Nebraska, an agricultural state whose farmers are dependent upon its water for the irrigation of their crops. Additionally, the "Big Bend" of the Platte, an 80-mile bow in the heart of the state, is a month-long stopover during the spring for 500,000 sandhill cranes. This stretch of the Platte—in the narrowest part of the cranes migratory tract—is extremely important to them because it is shallow enough to allow them to roost, less than 15 cm (6 inches), and wide enough, more than 607 meters (2000 feet), to provide them with security from predators (Gruchow, 1989). The Platte therefore provides them with a resting and feeding sanctuary on route to their breeding homes of Siberia, Alaska, and Canada (Fish and Wildlife Service, 1981).

In addition to the sandhill cranes, several threatened and endangered species, such as bald eagles, whooping cranes, piping plovers, least terns, and peregrine falcons, are found on the Platte. As a result, the National Audubon Society has made the preservation of the Platte River one of its major national initiatives (Winckler, 1989).

Conflicting demands between environmental advocates, recreational users, agricultural users, power production and irrigation facilities, and federal agencies surfaced recently in light of the Federal Energy Regulatory Commission's (FERC) relicensing of the power permits related to Kingsley Dam (project #1417), a major New Deal dam, and Keystone Diversion Dam (project # 8135), used to divert water for power production and irrigation (Cook, 1992). This long-term relicensing will manage the instream and diversion flows of the Platte far into the 21st century.

Kingsley Dam created Lake McConaughy as a reservoir to serve the power production and irrigation interests of central Nebraska's farmers following the droughts of the 1930s. As intended, it is now used for hydropower production and the irrigation of over 94,290 hectares (233,000 acres) of farmland by the Central Nebraska Public Power and Irrigation District (CNPPID) and the Nebraska Public Power District (NPPD) (Platte River Whooping Crane Maintenance Trust Inc., 1991). Additionally, Lake McConaughy serves as an annual recreational retreat for over 700,000 visitors, generating significant amounts of revenue. Finally, McConaughy acts as an upstream retainer of water (1.7 million acre-feet) that is critical to maintaining the downstream reaches of the Platte where the threatened and endangered species reside (Winckler, 1989).

Since FERC originally licensed these dams in July 1937, the growth of environmental concerns over such projects has been reflected in the passage of (1) the National Environmental Policy Act in 1969; (2) the Endangered Species Act in 1973; and (3) the Electric Consumers Protection Act in 1986. The combination of this legislation and the

designation of the "Big Bend" portion of the Platte River as an area of critical habitat for the endangered whooping crane in 1978 (Aiken, 1990) has significantly affected this relicensing process. Today, the Platte is identified as a critical habitat area for seven other threatened and endangered species.

Subsequently, FERC's Draft Environmental Impact Statement (DEIS) has been subjected to the task of trying to balance the interests of these disputants. Although FERC is currently relicensing several facilities, few match the magnitude and complexity of Kingsley and Keystone (McKitrick, 1993). This is due to the number of endangered species present on the Platte, the tremendous distance—322 kilometers (200 miles) on average—between the dams and the areas of critical habitat, and the passion of the disputants. While most FERC relicensings take 2 to 4 years, this relicensing has taken 10 years to date, at a cost of $20 million (Cook, 1993).

The Primary Disputants and Their Interests

The specific groups involved in this dispute are too numerous to mention here. The most important issue is to identify the fundamental groups that are most critical to the relicensing process. Quite simply, those groups are CNPPID and NPPD who represent the power production and irrigation interests, and the environmental community represented by The Platte River Whooping Crane Maintenance Trust Inc., or the Trust, and several national environmental groups. The Trust was legally established in 1978 as a dispute conciliation over the construction of Gray Rocks Dam on a major tributary of the Platte in Wyoming. Their mission is to act as a legal and biological watchdog over the critical habitat of the Platte River (Aiken, 1990).

It is these two interests, the power production and irrigation groups and the environmental communities headed by the Trust, that represent the primary clash of perspectives on the management of the Platte. The problem inherently lies in three basic issues:

1. The amount of water each group feels is needed to maintain critical habitat for the endangered species on the central Platte.
2. The amount of money needed to restore lost habitat from channelization and sedimentation changes on the Platte over time.
3. The future water conservation measures to be implemented within the diversion canals and systems and on the Platte (Chaffin, 1993; Currier, 1993; Mazour, 1993; Maher, 1993).

If these interests could come to a point of resolution on these three fundamentals, with guarantees that they will be enacted without significantly harming power production or irrigation—while protecting the endangered species—there is a strong probability that this dispute would be resolved.

Thus we have a conflict born of pluralism. There is an equal distribution of power, which is fundamentally good in a decision-making process. It also signifies that this conflict is not the result of chaos or bad intentions, but the result of an equalization in the manner in which this nation views its economic and environmental resources. This scenario presented a case that seemed primed for the mediation as a dispute resolution tool.

The Background of the Mediation Attempts

In order to address and resolve this controversy, the use of mediation as a form of alternative dispute resolution was initiated on two separate occasions. The unique attributes of mediation were seen as an option in resolving this environmental and economic conflict (Bingham, 1986). It was the hope of parties involved that a successful mediation attempt would keep them from resorting to pronounced legal battles over FERC's preferred management alternative.

Mediation was seen as the most efficient means of facilitating communication among the parties and drawing them together in a management agreement that would be acceptable to all sides. Despite this hope, the significance of the issues outlined above along with flaws in the relicensing process provided an atmosphere of negotiation that was not conducive to mediation procedures.

The first mediation took place in 1989 with John Folk-Williams as the mediator. The initial attempt of this mediation was to resolve a dispute over the annual permits that CNPPID and NPPD were operating under. However, the ultimate goal of the mediation was to resolve the conflict

(Chaffin, 1993; Czaplewski, 1993). Resolution in this mediation was hinging on three disputes, the primary one being how much money the districts would spend to restore critical habitat on the Platte. Although a rough agreement had been discussed on the two other issues—instream flows and diversions, and water conservation measures—they were not written in stone. However, if the disputants had been able to resolve the issue of habitat restoration costs (the difference was several million dollars) this specific mediation attempt may have been successful (Mazour, 1993; Maher, 1993; Cook, 1993; Chaffin, 1993).

The second mediation took place in 1991 and was mediated by Howard Bellman. The attempt of this mediation was to establish a "Nebraska Solution" to submit to FERC as a management alternative in their DEIS. Although a majority of the disputants felt that Bellman did everything in his power to resolve the issue, there were too many delays in the process and several disputants appeared to be unwilling to negotiate with concession. It appears that at this point a great deal of polarization was beginning to take place, probably due to the longevity of the dispute and the issues being addressed. It turned out that the process was not ripe for mediation (Bellman, 1993).

The following nine elements have been consistently identified in mediation literature (Bingham, 1986; Crowfoot and Wondolleck, 1990; Moore, 1986) as being critical to obtaining a resolution:

1. Selecting the appropriate time for mediation intervention.
2. Identifying, incorporating, and educating all disputants.
3. A belief by the disputants that mediation is better than litigation.
4. Effectively gathering data.
5. Creating ample and/or unique options for solution.
6. Displaying incentives for resolution and facilitating a willingness to compromise.
7. Establishing the goals of the parties.
8. Creating the presence of a deadline.
9. Including the implementation agency in the mediation process.

To summarize, in the first mediation attempt it appears that the only elements present were numbers 1, 4, 7, and 8. In the second attempt the only elements present were 4 and 7. The significant lack of the other elements critical to the process prophetically forecasted the outcome of the mediation attempts. It is imperative to examine why these elements were missing and what groups contributed to the ineffectiveness of the mediations.

Why the Mediation Attempts Failed

Environmental mediation attempts are often addressing such extensive, complex, and polarized issues that selecting specific points of failure may not comprehensively critique the process. However, in the research that has been conducted, there were several reoccurring areas of failure that were corroborated by the disputants in controversy. The five factors that have been identified as the critical aspects that contributed to the failed mediations are:

1. The timing of intervention, the lack of deadlines, and the lost sense of urgency.
2. The lack of incentives for the parties to expediently resolve the dispute.
3. The unwillingness to bargain due to perceived litigative strength.
4. The lack of information and concrete data for unresolved issues.
5. The absence of active participation by FERC and the Fish and Wildlife Service (Currier, 1993; Mazour, 1993; Maher, 1993; Czaplewski, 1993; Barels, 1993).

Coincidentally, these areas are direct antitheses to the elements critical for effective mediation previously mentioned. It is the cumulative effect of these problem areas that is fundamentally responsible for the flaws in the mediation processes and the prolonged state of dispute on the Platte. There are several unique situations that contributed to these five failure factors that are examined below.

The Timing of Intervention, the Lack of Deadlines, and the Lost Sense of Urgency

A highly debated topic in the mediation field is the point at which intervention by the mediator should occur (Moore, 1986). Arguments are made for late intervention and for early intervention with quality reasoning given for each (Moore, 1986; Bingham and Haygood, 1986). However, in both of these mediations it was clear that the intervention was premature. The conditions for compromise were not

ripe and several of the parties involved were unwilling to compromise. Howard Bellman felt that his intervention was much too early; he feels that late intervention rarely takes place. His argument was rooted in the fact that a fundamental lack of *urgency* was present during the mediation. He felt this lack of urgency was based on the fact that no deadline was established for the mediation or the relicensing. Additionally, during the mediation FERC was in the process of publishing their first DEIS, which gave the parties an incentive to "wait and see" rather than decisively mediate (Cook, 1993; Currier, 1993; Mazour, 1993; Barels, 1993).

This intrinsic lack of urgency to resolve the dispute was apparent in many areas. Currently, CNPPID is operating on annual permits (that have been legally forced by the Trust to take into consideration the endangered species). It has been argued by the environmental community that this annual permit process gives CNPPID no major incentive for resolution (Currier, 1993). On the other hand, CNPPID would argue that the national environmental communities that are involved lack a sense of urgency to resolve this issue because of the valued attention it is drawing to their cause (Mazour, 1993). Both of these arguments may be valid, while reemphasizing the fact that this resolution was not pending enough to move these groups to conciliation.

To further distract from the urgency of resolution, FERC issued a DEIS and is now issuing a revised DEIS. Following its submission and a period for comments by the disputants, the Fish and Wildlife Service will enter the arena to evaluate the impact on endangered species. Examining this sequence, it becomes strikingly clear that the basic sense of urgency to resolve this dispute was, and is, absent. In this author's opinion, this would also seem to indicate that the Platte River and its endangered species are in no immediate danger.

The Incentives of the Parties to Resolve the Dispute Expediently

This area goes hand-in-hand with the urgency area discussed above. However, the distinction is that the lack of urgency can exist in the entire process, while the lack of incentives can reside within one party and ultimately destroy the mediation process. For example, the national environmental interests are perceived to have minimal incentive for resolution. However, the Trust argues that that point is negated by the fact that they are performing the role of those national interests in this scenario. As a result, the Trust feels, contrary to the public power districts, that the absence of the national environmental interests would not bring this dispute closer to resolution (Currier, 1993).

The views expressed above indicate that the presence of parties that were unwilling to negotiate may have created a sense of antagonism "across the table" that promoted further polarization of the parties. It is somewhat self-evident that the parties have to have an incentive to resolve the issue. If they do not, perhaps their place at the mediation table should be reserved for those who do.

The Unwillingness to Bargain Due to a Perception of Litigative Strength

One of the basic concepts of mediation is that it is an alternative dispute resolution measure to litigation. In a mediation attempt it is imperative that all of the groups come to the table with the idea that they can conceive a win/win outcome that will be more acceptable than the risking a win/lose verdict in court (Crowfoot and Wondolleck, 1990). In this case, the perception on the part of several groups that their chances in court were better than the alternatives being offered through mediation was widespread and severely handicapped the process. In essence, when it came time to negotiate the incentive was not there and thus the fundamentals of mediation were unattainable.

The Lack of Information and Concrete Data for Unresolved Issues

This problem primarily refers to the science of identifying exactly what type of habitat maintenance is needed for the endangered species. The use of models to examine the possible scenarios present under certain operating conditions was one method used to explore the needs of the species. The use of models was a concern in the second mediation because of the interpretation of results and possible biases in the data processing (Barels, 1993; Czaplewski, 1993; Mazour, 1993; Maher, 1993).

This problem is often a major obstacle for environmental mediation. To determine with accuracy the amount of water that these species need takes a vast amount of time and resources, and the results may never be certain. In fact some of the first biological studies on the Platte were conducted as a result of this relicensing (Barels, 1993; Czaplewski, 1993). Consequently, groups are consistently lacking concrete data that is critical to making river management decisions. Eventually it must be accepted these this insufficient data are inherent to any environmental dispute and mediation should be carried out with such a perspective.

The Absence of Active Participation by FERC and the Fish and Wildlife Service

In both of the mediation attempts a resolution by the groups did not guarantee a resolution of the relicensing. If they had reached an agreement, that agreement would then have to be accepted by FERC as their preferred alternative in their DEIS, and then that alternative would have to be rendered a "non jeopardy" judgment for the endangered species by the FWS. It therefore seems reasonable to expect willing and active participation by both of these groups at the mediation table. However, in these mediations, FERC consistently did not participate in the mediations because of the very tedious steps they had to go through to prevent ex-parte communication (Cook, 1993). FWS passively participated in some sessions, but their feedback was minimal. They waited until after the mediation attempts, when the State of Nebraska came up with a plan on their own, to severely criticize its effects on wildlife, rather than making those criticisms at a point when they could have been addressed.

Perhaps the most important point in a mediation attempt is to have all of the critical groups present. Their active and consistent participation is crucial. If FERC and the FWS expect future relicensing processes to proceed more expediently, they are going to have to revise their guidelines for participating in mediations. Although FERC is proposing regulations to do this under a plan called consolidated application process (Barels, 1993; Czaplewski, 1993), the complete incorporation of FWS will be vital to preventing these prolonged disputes.

Conclusions for the Platte Controversy

Environmental controversies are never simple. The "nature of nature" presents us with a world of uncertainties. For mediation to be effective in disputes as complex as the Platte's, several changes will have to occur.

First, the underestimation of such controversies will have to be avoided. Earlier communication between the disputants and earlier scientific research is going to have to take place. All of the disputants contacted in this case study agreed that if the initial efforts toward resolution would have been more spirited, the escalation of this dispute could have been curtailed.

Second, groups that have little at stake, such as the national environmental groups whose interests were represented by the Trust, should perhaps be omitted from the process. These groups are usually geographically, economically, and socially separated from the dispute; and it is a common perception that the hardline approach these groups foster creates major resolution obstacles. Perhaps the dispute could be more conveniently resolved by those interests that have a direct stake in the outcome along with the implementing agencies. They are the ones who will have to live with the implemented decisions, not the national environmental interests.

Finally, FERC and the FWS may have to reevaluate the manner in which they relicense these projects. Previously identified problems indicate that the current relicensing process creates no sense of urgency to resolve conflicts. Additionally, even if the disputants conceive a resolution alternative, there is no guarantee that FERC or FWS will accept it. Therefore it is essential that FERC and FWS become intrinsically involved in the decision making attempts by the parties. If they do not, in future relicensings, vast amounts of time and money will continue to be fruitlessly invested into resolution processes that will be doomed because they are severely lacking adequate incentives.

The pluralism of this dispute, although it may not appear to be, is to the benefit of all. The Platte's predicament is unique. The future of the world's species is as important as the future of agriculture in central Nebraska. The reason that this dispute has yet to be resolved is partially due to the very convincing arguments that both sides espouse. Resolution of this controversy

should not reside in a decision dictating which side is correct, it should be found in a management plan that balances the multiplicity of interests. Environmental mediation is a tool that can accomplish this if it is appropriately formatted and conducted.

In conclusion, the fundamental issue underlying an environmental dispute is the rudimentary call for compromise and conciliation. We need to accept the fact that our heightened awareness of our impact on the environment has thrust us into era that places the need for coordinated management alternatives that place environmental needs above individual beliefs and desires. In this case study, it is important for the disputants to realize this before they are left with a management alternative, dictated by an outside agency, that may be less attractive than what they could have mediated themselves.

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Umatilla Watershed Restoration: Success Through Cooperation

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The Confederated Tribes of the Umatilla Indian Reservation have been caught up in several conflicts over the management of natural resources. We are committed to resolving these conflicts in a cooperative and proactive way and have been very successful in doing so.

Before describing some examples, I would like to give you some background on my tribe. The Confederated Tribes of the Umatilla Indian Reservation is made up of the Umatilla, Cayuse, and Walla Walla Tribes. Before the Treaty of 1855, our tribes had a thriving fishing economy. We traded salmon up into Canada, down into California, and far to the East for goods from those regions. We were a wealthy, self-sufficient nation at that time.

In 1855, our tribes entered into a treaty with the U.S. government in which we ceded 6.4 million acres in what are now the States of Oregon and Washington. Certain rights, however, we never gave up and we reserved them in the treaty. These rights include the right to fish and the right to a sufficient quantity and quality of water to maintain these fish runs. The reservation of our treaty fishing rights meant the protection of our culture, our religion, and our economy.

Over the last several decades, we have watched the salmon in our treaty- protected fishing areas disappear. The construction of the Hell's Canyon Dam on the Snake River resulted in the complete extinction of all anadromous fish in the entire Powder, Burnt, and Malheur watersheds. Mainstem dams and tributary habitat destruction have driven salmon to the verge of extinction in the Grande Ronde, Imnaha, and Tucannon watersheds, where they have become listed under the Endangered Species Act. The Umatilla watershed, however, stands out in a bright contrast even though it started out in just as bad a situation.

As those of you who work with federal agencies know, the federal government has a trust responsibility to tribes. This special relationship requires that the federal government protect tribal treaty rights and treaty resources. It also recognizes that states and neighbors of tribes are often hostile and that the federal government has a special obligation to protect tribes from this hostility.

In the early 1900s, however, the Bureau of Reclamation built five major dams on the Umatilla River. It then took the water which our tribe had reserved under the treaty and gave it to irrigation. What had been desert became farmland, but during many months of the year no water reached the mouth of the Umatilla River. This drove the salmon in the Umatilla River into extinction over 70 years ago. It also pitted our treaty-reserved water rights against water rights issued to irrigation interests by the state and federal governments. In doing so, it pitted our fishing economy against this ne / irrigation economy.

Instead of fighting against the irrigation interests, however, we worked with them and with the Oregon Department of Fish and Wildlife to develop the idea of the Umatilla Basin Project. Then we took it to the Bureau of Reclamation and in 1988 Congress authorized the project. This project exchanges Umatilla River water for Columbia River water, leaving flows in the Umatilla River for fish.

By developing this cooperative solution, not only are we preserving the

stability of the local economy, but we expect to add over $8 million annually to the regional economy through the restoration of the Umatilla River salmon runs. Conflict between treaty reserved water rights and historic non-Indian usage exists throughout the West. Where tribes are beginning to exercise their water rights, hostile conflict is usually the result. What makes our "win-win" solution especially unique is that we sat down and began developing a solution before the conflict had developed into litigation.

This cooperative solution has also become a model for salmon restoration. We have begun to bring salmon back to the Umatilla River, with the Umatilla Basin Project and with other cooperative efforts. While the numbers of salmon are declining throughout the other Columbia and Snake River tributaries, the number of salmon are increasing in the Umatilla River.

My tribe's commitment to developing cooperative solutions when possible resulted in another success last year. Some environmental groups, trying to make changes in western water policy, gained attention by asserting that state and federal water policies would undermine the fish benefits of the Umatilla Basin Project. The resulting conflict became increasingly divisive and, due to the failure of the parties to negotiate a solution, was headed for litigation. This tribe stepped into the conflict and took the lead in establishing real negotiations.

The parties to the negotiations included three environmental groups (including the Oregon Natural Resources Council, one of the primary plaintiffs in the spotted owl litigation), four irrigation districts, two state agencies, two federal agencies, a local chamber of commerce group, and this tribe. After two and a half months of intensive negotiations, the 13 parties developed a consensus solution to all of the issues that had been raised. This cooperative approach not only resolved the conflict but expanded the coalition supporting the Umatilla Basin Project.

In the Grande Ronde watershed, we are putting together a similar coalition to cooperatively restore salmon and salmon habitat. The salmon in this Snake River sub-basin are listed under the Endangered Species Act. Working with some of the best watershed ecology and fish biology experts in the United States, we developed the Upper Grande Ronde Salmon Habitat Plan. This plan is the state of the art in terms of forest management standards aimed at restoring watershed level salmon habitat. This plan has been recognized as a model for salmon habitat restoration by the Endangered Species Act Recovery Plan Team. We are now working with timber, grazing, irrigation, and environmental interests as well as with state and federal agencies to implement this plan.

This tribe, through the Northwest Power Planning Council's and Bonneville Power Administration's model watershed process, has extended the application of the plan's objectives to the entire sub-basin. We have developed a coalition with two counties to implement these habitat restoration measures throughout the watershed.

Again, the underlying principal in developing and implementing this plan has been to address everybody's needs. We have demonstrated that environmental restoration does not have to severely impact other resource users. Relatively minor modifications of existing practices may have major benefits for fish.

We see no reason why the conflict over Columbia and Snake River salmon recovery could not be resolved in a similar manner. The Umatilla Basin Project should serve as a model for addressing Snake River flow and passage problems. We have shown that water can be reallocated for fish needs without putting people out of business. We have also shown that apparently impossible legal and political conflicts can be resolved through cooperation. The Upper Grande Ronde Plan should serve as a model for tributary habitat restoration throughout the Columbia and Snake River basins. We have shown that a technically sound approach to salmon recovery can be compatible with other uses of the resource.

I have discussed two watersheds as examples. One is under Endangered Species Act constraints; the other is not. Both, however, are focused on salmon restoration. We have an opportunity to make both work.

Salmon is the resource which defines the Pacific Northwest. This is probably our last opportunity to restore this critical resource. For this effort to be successful, the federal agencies will need to begin to play a greater leadership role.

Lastly, I want to point out the obvious. Many different entities have attempted in the past to restore habitat and salmon in the Umatilla, Grande Ronde and in the Columbia River system as a whole. The tribes have been successful because they can break

down the traditional barriers separating factions such as environmental groups and industry. Further, because of our government-to-government relationship with the federal government, we can work closely with federal agency representatives—more closely than most of you are used to working with entities outside of your agency sphere.

When my ancestors negotiated the Treaty of 1855, they planned for seven generations into the future. That is why they specifically reserved our right to fish in the treaty. I am one of those children that they were thinking of and planning for in 1855. I have a duty to them to see that the salmon are restored. I also look to the people of the United States who were parties to the treaty as well to ensure that the treaty promises are fulfilled. It is time for all of us to begin working together to plan for the next seven generations.

Large-Scale Collaboration—Lessons Learned

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If watershed management is to be a sustainable reality, proponents must develop the knowledge and skills to effectively initiate and participate in inter-organizational collaboration on community-wide and regional scales. A substantial track record has been built up in the application of consensus-building tools to specific disputes over natural resource management and environmental quality, but community-wide consensus-building efforts ("community collaboratives") are a newer "animal"—particularly in the environmental arena.

This paper extracts the lessons learned from the growing number of community collaboratives under way in the social services arena and integrates them with the author's 9 years of experience in environmental dispute resolution to generate suggestions for what watershed management proponents should know about community-wide and regional collaboration to maximize chances of success in watershed management. In identifying the lessons learned from social services collaboratives, the author draws extensively from a literature review conducted at the request of the Program for Community Problem Solving by Kathleen A. Blank (unpublished mimeo, 1993).

"Community Collaboratives" Defined

For purposes of this paper, the term "community collaborative" means a project that is designed to address a specific policy or administrative issue in a particular community and has the following characteristics.

1. *Representatives of all stakeholders are involved.* As in environmental dispute resolution efforts, stakeholders who need to be represented include those individuals or organizations significantly affected by the issue, those who could help ensure implementation of a solution, and those who could block implementation of a solution.
2. *Collaboratives entail broad, significant, and continuous outreach to, and involvement of, organizations in both the public and private sectors, as well as individual members of the public* (Himmelman, 1992). While environmental dispute resolution processes frequently involve some form of supplementary public involvement (e.g., a public comment period on a regulation that has been negotiated by a representative core group of stakeholders), public involvement plays more of a driving role in the most effective community collaboratives.
3. *Participants rely upon consensus as their primary method of decision-making.* This characteristic is also similar to environmental dispute resolution forums. For purposes of this paper, the term "consensus" refers to a method of decision-making in which participants discuss a shared problem and possible solutions until they come up with a solution that all can accept. Each participant, in effect, has veto power over proposed solutions.
4. *Participants think of the project as a long-term undertaking, and one that involves implementation as well as*

decision making. In contrast to many other kinds of consensus-building forums that culminate when a consensus decision is reached, community collaboratives tend to put considerable emphasis on implementation of such decisions. For this reason, collaboratives typically have a multiyear time-frame.

5. *Participants' interactions go beyond networking, coordination, and negotiation to encompass (a) resource and risk sharing and (b) changes in the way participants do business, both of which reflect participants' shared "meta-strategy" for achieving a common goal.* Collaboratives typically entail the creation of new and modified organizational structures, policies, and procedures. This might take the form of a new governing entity for the collaborative project as a whole or changes in the way participating organizations operate. Such structural changes are undertaken in the service of a shared "meta-mission" and "meta-objectives"—components of a strategy that cannot be achieved without the joint efforts of participants in the collaborative (Huxham and Macdonald, 1992).

While negotiated agreements resulting from environmental dispute resolution processes *sometimes* include provisions for resource and risk sharing and structural changes within participating organizations, these things are *typical* in a community collaborative and are generally worked out early in the course of the project, rather than as a part of a final agreement.

Community collaboratives have typically been initiated in the social services arena to address issues such as how the delivery of various social services (e.g., health care, income subsidies, job training, etc.) can be integrated to more effectively meet the needs of individuals and families. However, a growing body of experience with, and support for, watershed management suggests that community collaboratives may be effective vehicles for operationalizing this approach to natural resource management.

Relevant traits shared by the social services and watershed management arenas include the fact that both require intensive cooperation and coordination among federal, state, regional, and local organizations, as well as between the public and private sectors, to accomplish technically complex goals. They both require the active participation of the public to be effective, and programs in both of these arenas must be tailored to unique characteristics of a particular locale. The remainder of this paper discusses community collaborative models transferable to watershed management and relevant design criteria for translating such a model into action.

Collaborative Models—"Betterment" Versus "Empowerment"

One of the themes that characterize the literature on social services collaboratives is the importance of designing the collaborative in a way that is empowering to the community. Himmelman (1992) delineates two distinct models upon which community collaboratives have been patterned—the "collaborative betterment" model and the "collaborative empowerment" model.

Under the betterment model, the project is initiated by large institutions, sometimes based inside the community and sometimes outside it. The governance functions of the collaborative are often controlled by the most powerful of these institutions, and the collaborative's action plan tends to reflect primarily the ideas of associated professionals. While community involvement is elicited as a way of gaining acceptance for the action plan, this tends to happen late in the game and control of resources and the decision-making process remains with the initiating institutions.

Under the empowerment model, the genesis of the collaborative lies in local dialogue about community values, beliefs, assumptions, activities, and needed changes; such dialogue lays the foundation for the development of the community-wide vision needed to sustain a long-term change effort. The community residents themselves determine the focus of the collaborative, the issues to be addressed, the local and external organizations that will be invited to participate in collaborative activities, and how power and responsibilities can most equitably be shared. It is community representatives who negotiate the details of the collaborative's concluding phase in such a way that the community is left with the resources and capacity needed to sustain implementation

activities over the long run. Community involvement is continuous.

A variety of writers have argued in favor of the empowerment model, whether or not they called it by this name (Himmelman, 1992; Chavis et al., in press; Brunner, 1991; Meltzer, 1991; and Jones and Silva, 1991). The key advantages of this model are that (a) the community has a much stronger sense of ownership in the collaborative project, which is critical in designing a project that is responsive to community needs and in developing and sustaining the resources and commitment needed to carry the project through implementation, and (b) the community's capacity to effectively solve local problems is enhanced, reducing the need for external support in the future.

However, community collaboratives are not cheap; and in the current economic climate, it is difficult for many communities to finance such projects solely with local resources. External funding institutions, such as federal and state agencies and foundations, may be interested in supporting a series of concurrent community collaboratives in different localities around the country as a way of accomplishing a particular policy objective (e.g., reducing infant mortality rates or nonpoint source pollution); yet they may be wary of the empowerment model because it calls for relinquishing some of the control they are used to having over projects they are supporting. Representatives of such institutions may worry about how success will be ensured and about issues of accountability, both internally (e.g., to boards of directors or agency administrators) and externally (e.g., to Congress). These concerns are understandable; the following section offers one way of addressing them.

Designing a Community Collaborative for Watershed Management

External funding entities can be reassured about accountability and the likelihood of the success of a collaborative, although they are sharing control of it with all other participants, by including certain design elements in the project that have been associated with successful collaboratives. Drawing from the literature on social services collaboratives, a community collaborative initiated as a vehicle for watershed management should include the following characteristics.

1. *The project should be convened by someone whose leadership reputation, interpersonal skills, and group management capabilities convey a sense of legitimacy* (Mattesich and Monsey, 1992).
2. *The collaborative should be administered by a carefully-thought-out governance entity.* For example, an organizing committee might be established to handle preliminary administrative tasks, such as meeting with representatives of organizations the community suggests as potential participants to determine which of these organizations should be asked to participate. Once membership stabilized, the organizing committee might give way to (a) a policy board that meets quarterly to provide overall project guidance and to advocate for policy changes sought by the collaborative; (b) an executive committee that meets monthly to provide ongoing administrative and program guidance; and (c) action groups, each responsible for developing an action plan for a single goal (Himmelman, 1992). Meltzer (1991) suggests that the governing entity should combine planning and communication functions with "more authoritative efforts to redirect financing and assess system performance."
3. *The project should be adequately and consistently staffed and funded, with a staff composition reflecting the diversity of communities served* (Meltzer, 1991; Chang, 1992). The number of staff needed will vary according to the collaborative's mission and scope and the degree of member involvement in day-to-day functions of the collaborative (Meltzer, 1991).
4. *The collaborative's public outreach and internal interactions should reflect an understanding, acceptance, and accommodation of cultural differences in values, communication methods, and approach to the target issue (e.g., health care or waste disposal)* (Center for Community Education, 1991; Himmelman, 1992; Chang, 1992). Such outreach should begin

very early (i.e., at the problem definition stage) (Meltzer, 1991) and should not be limited to groups who have previously participated in community decision making (Center for Community Education, 1991). Mattesich and Monsey (1992) urge that open communication should be the watchword and that it should occur both in writing and in person. Chang (1992) points out that "the outcome of a collaborative is often determined by the ability of the individuals involved to respect each other as equals, establish trust and work constructively together. But group dynamics are often shaped by historical power relationships which are neither respectful or equal, and the complexity becomes greater when members of different racial groups are involved." Participating organizations need to be open to making changes in their policies and procedures based on input from other participants and the public regarding the impacts of existing practices.

5. *Goals, objectives, roles, rights, responsibilities, and lines of accountability should be clearly-delineated, agreed-upon by all participants, and communicated to the public* (Himmelman, 1992; Meltzer, 1991; Mattesich and Monsey, 1992). To ensure adequate assessment of problems and outcomes, the collaborative's governance entity should be accountable for the overall welfare of those served by the collaborative and for the results of the services provided (Meltzer, 1991).
6. *Participants should focus on only a few key, attainable goals.* This will help ensure timely progress, which is vital to sustaining momentum (Himmelman, 1992). These goals should not completely overlap those of any of the member organizations (Mattesich and Monsey, 1992).
7. *Participants should remain open to reviewing and, if necessary, modifying the collaborative's mission statement, goals, and action plans throughout the project.* The willingness to do this is important in sustaining the full support of the community, institutional participants, and new members of the collaborative (Himmelman, 1992), as well as in accommodating changes in the external environment (Mattesich and Monsey, 1992).
8. *Participants should develop problem-assessment instruments that they use in common* (Meltzer, 1991). This will support the development of a shared understanding of the problem and minimize conflicts over data.
9. *Participants should collect data on similar projects in other communities.* Such information can be invaluable in developing an effective local strategy (Himmelman, 1992).
10. *Participating organizations should involve both management and operations staff in the collaborative's activities, and should initiate internal steps to ensure that their "bean-counting" systems reward, rather than discourage, employees from contributing to the collaborative project* (Mattesich and Monsey, 1992; Brunner, 1991).
11. *When conflicts or technical challenges arise, tightly structured processes should be devised to address them effectively* (Jones, 1990). *Project plans should make provisions for obtaining facilitation services, training in problem-solving skills and cross-cultural dynamics, and technical assistance as needed* (Himmelman, 1992; Chang, 1992). In some cases, local government agencies may be able to provide qualified personnel to perform these functions; however, if neutrality or other credibility issues make this problematic, consultants may be needed.
12. *Participants should establish a project evaluation mechanism.* Progress should be measured in terms of outcomes in relation to resources expended (Brunner, 1991), and strategies and action plans should be adjusted accordingly. Meltzer (1991) recommends that the governing entity serve as a central repository for evaluation data and that these data and the collaborative's analysis of it should be available to the public.
13. *Throughout the project, participants should attend not only to*

problem solving, but also to community building and systems interaction (Jones and Silva, 1991). When problem solving is pursued without concurrent attention to community-building efforts, resulting actions are likely to occur without a sense of ownership by community members. Pursued without awareness of the ways in which collaborative activities will trigger changes in surrounding systems, action will lack direction and have unintended results.

Mattesich and Monsey (1992) also note that the success of collaborative efforts is increased where there is a history of collaboration in the community, where community leaders support the collaborative's mission, and where participants share a vision and believe that the benefits of collaboration in realizing that vision outweigh any associated loss of autonomy.

Conclusion

In the current climate of economic austerity, the relationships between federal, state, regional, and local governments are shifting, as is that between the public and private sectors. This era calls for national funders in both the public and private sectors to increasingly leverage their assistance to state, regional, and local entities in a way that helps the smaller jurisdictions to help themselves. The community collaborative model is an ideal vehicle for implementing such efforts on behalf of watershed management. Parties wishing to speak with those who have piloted such programs in other policy arenas may call the Program for Community Problem Solving (202-783-2961) for contact information.

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Mushing Watershed Projects Together in Iowa

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Contrary to popular belief, Iowa has a great deal of variety in landscapes. From the Mississippi on the east to the Missouri River on the west, from the Karst topography of northeast Iowa to the depth loess in western Iowa, we have a great deal of variety in our soils and resources.

Agriculture is an extremely important industry in Iowa. Of 36 million acres, we have 27 million in cropland, of which approximately 21 or 22 million will be in corn or soybeans each year. We also produce 26 percent of the pork, are one of the top beef producers in the United States, and have a growing poultry industry.

Water is an economic issue in Iowa. We either have too much, too little, or not enough good quality water. For the same reasons, water is an environmental issue. Iowa has been a leader in conservation issues with soil conservation laws, state erosion control cost-share programs, and ground water protection.

Iowa is not a very densely populated state with approximately 2.8 million people. There is a diversity of concerns, interests, and almost universally inadequate funding. We have concluded that the best way to implement projects for whatever reason is to use a variety of programs, agencies, skills, groups, etc. We call it mushing.

From the Soil Conservation Service's (SCS) standpoint, we have developed skills through planning and installing watershed projects since the late 1940s. We currently have 20 operational P.L. 566 watersheds and 17 operational P.L. 534 subwatersheds. We have learned many valuable lessons from this experience, have developed many important partnerships over the years, and have used this knowledge to help develop many other projects. As a result we are actively involved in approximately 70 operational water quality improvement projects in the state with support from 13 different funding sources. Approximately 50 are operated on a watershed basis.

No one knows exactly how to mush correctly. In fact, I'm not even sure how to spell it, but here is how we do it. First of all, we talk to each other. As simple as it seems, this is the most important factor in making our process work. We do not really have a formal organization, but we do have an informal but fairly tight knit group of people who work together quite often. This includes representatives from different divisions of the Iowa Department of Natural Resources; Iowa Department of Agriculture and Land Stewardship, Division of Soil Conservation; the Cooperative Extension Service; and the SCS. In addition, there is a much larger coalition involved in the issue made up of other agencies, commodity, and environmental groups.

When planning individual projects, each group needs to think in terms of what they can give to the project, not what they can get from the project. You have to leave your individual egos as well as agency egos at the door and work for the best interest of the individual project. You will all win eventually. If you do not win on this one, you will win on the next one.

The second important factor in making this effort work is talking to the local people, getting them involved in determining what the problems are and what the solutions are. We try to be comprehensive and help local people develop information from which they can agree what problems will be dealt with or opportunities developed. We always have private landowners involved since about 98 percent

of the state is privately owned. In most cases there are multiple sponsors including Soil and Water Conservation Districts, Department of Natural Resources, municipal water supplies, and county governments.

Once we have an agreement on the problems, we can begin looking at the solutions. We work through the alternatives with the sponsors to see which ones are the most acceptable socially, economically, and environmentally. Then and only then do we start worrying about money. There are too many cooperative watershed projects that fail because people worry about fitting problems into specific programs. If you are blind to a problem because of program constraints, you will dismiss it because you cannot pay for it, not because you can not solve it. That is why we identify the problems and the solutions before we start worrying about how or who is going to pay for it.

In water quality projects, for example, I mentioned earlier we use about 13 funding sources. These include local, state, SCS, and EPA financed programs. For mushing water quality projects together, we use a generic application procedure. The application is reviewed by people from several agencies that may assume responsibility for all, part, or none of the project. If an application is chosen, it is then decided who has money that could go towards solving the problem.

Another prerequisite for cooperative projects is to keep administrative procedures tolerable. A variety of funding can be very confusing to the local people, especially when dealing with multiple budgets. We have one project, for example, that has seven funding sources. We administer the programs as consistently as possible with the way local people are used to doing business. For example, Iowa has a state cost-sharing program. Through section 319, funds are passed through the Division of Soil Conservation, which passes them on to the involved soil and water conservation district. It is business as usual for cooperators and staff except they are using a different accounting number for that individual project.

Now we have financing in place and it is merely a matter of implementing the program. Another key element is to make sure everyone is informed about the program, what it is intended to accomplish, and what it is actually doing. This includes the landowners as well as leaders at the local, state, and national levels. Some projects publish newsletters; all write articles for the local paper and, of course, make one-on-one contacts. We try to build in funding on the larger projects for a project coordinator. With the heavy workload in our part of the world we feel it is important to dedicate a person to the project. Part of this person's responsibilities is to make sure the public is informed and knowledgeable about what is going on in that project. On larger projects a person with communication training may be assigned to do this job. We also establish a local Steering Committee made up of area farmers who are involved in implementing the project and make sure they have a complete understanding and are involved in the decision making and guidance of the project. This helps cut down on the coffee shop rumors and provides the public with an informal but effective way of transforming their wishes and their thoughts on that particular project to the governing board.

Every good news story tells who, what, when, where, why, and so what. The "so what" is very, very critical to us and we always try to address it as part of the program. The "so what" is: What did you actually do? What did you actually accomplish? How do you measure it? How do you relate it to people who are important in the decision making process? This is probably one of our major oversights in P.L. 566. We tell people what we did but in terms that make little sense to them, e.g., BC ratio, acre-feet. We need to tell them the "so what" in terms they can understand.

We do a little bit of everything to address the "so what" question. One of them in water quality projects comes down to measuring or gauging social changes. It is very difficult to identify water quality impacts from implementing projects in the short run. What we are trying to do is change behavior. We are trying to change the way landowners take care of the land, water, and wildlife. We also try to approach it from the standpoint that we have something to give them and are not just wanting to ask them to do something. In this case the "so what" to the producer is improved profitability of the farm and environmental protection for society. For example, as a result of various programs around Iowa dealing with commercial fertilizer application, the nitrogen rate has decreased from about 145 pounds per acre on corn to approximately 117 pounds since the mid '80s. This saves farmers money because

yields have been maintained and costs reduced, while at the same time it is protecting the environment by reducing nitrogen loadings.

Our social survey at the beginning of a project tells us what farmers are doing or think they are doing. This provides valuable data to fine tune the project so that it meets their needs as well as society's needs. This might be in the form of incentives, cost-share, or information-education that leads to changes in how they farm. We go back midway through the project to see how the project is being accepted, how they have changed their farming practicing, and what they are now thinking. We can then make mid-project adjustments. The results from some of our work in northeast Iowa show that nitrogen application, for example, does not show up through the ground water system until 2 years after the changes have been made. Physical data are nice, but it is important to get a reading on what is happening in the project before it is too late to make changes. The final survey documents changes in attitudes, perceptions, and practices of producers in the project area. It also gives us excellent information to use with the decision makers to show that adjustments are being made, and the program is being accepted, implemented, and working to decrease adverse environmental impacts.

Everyone who has ever baked cookies knows that you burn a batch every once in a while. We have burnt our share having had both successes as well as failures. The important part is "WE." It is always easy to take credit for successful projects and place blame for failure. I am certainly not here to tell you we always agree and we maybe even mumble once in a while. By working together we can all take part of the credit, if due, or part of the blame, if it is due. It strengthens all agencies, groups, and individuals involved. Mushing is an inexact science but with the magnitude of the problem and limited resources it is the only game in town for Iowa.

HAPPY MUSHING!

Improving Local Efforts to Resolve Watershed Management Problems

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When most people think of Oregon, they usually think of dense evergreen forests, snow-capped peaks and abundant precipitation. Although rain and snow equivalents can be up to 100 inches, people are really surprised when they hear about vast areas within the state that receive only 10-20 inches of precipitation annually. These differences create a very complex hydrology within the 18 drainage basins of the state.

In addition, most of Oregon drains into the Columbia River. At one time, the mighty Columbia was the gateway to millions of salmon and steelhead that returned from the Pacific Ocean to spawn. Today, even with an extensive hatchery program that provides 80 percent of all fish returning to the Columbia, only one-fifth of the original numbers make their way upstream to spawn. Wild strains of sockeye and Chinook salmon have been listed as threatened or endangered species, putting even greater emphasis on the need for watershed management. More listings appear to be on the horizon.

Numerous other issues have come to a head in recent years. Excessive water temperature, industrial contamination, agricultural and municipal pollutants, and other water quality concerns have been identified as serious problems. Treaty rights for Indian tribes date back to the 1850s. These include the right to fish not only within their reservations, but throughout the area originally ceded by tribes, which includes virtually the entire Columbia Basin system.

These issues and others have brought water resource problems to the forefront of discussion within the State of Oregon. Citizens from all backgrounds have become more aware of water issues in recent years. Various groups have formed to challenge traditional water use and others are continually petitioning to list additional fish as endangered species. Legislators have been paying close attention to their constituents in attempts to draft water resource laws that address the issues. Population growth in western Oregon has driven laws to address water quality and quantity concerns along with federal mandates which must be met.

Underlying these issues are the concerns of local landowners and users of the water resources. A way of life that had its foundation set by the pioneers who came over the Oregon Trail 150 years ago has come under question. Water used by irrigators has come under closer regulation with stricter enforcement and interpretation of water right laws. Permits issued by the State Water Resources Department for the use of water by individuals, municipalities and economic development districts are becoming harder to obtain. In-stream needs must be determined and protected with in-stream water rights. State and federal wild and scenic river designations have placed further restrictions on water use. The finger of blame for fish habitat problems and reduced runs of salmon and steelhead has pointed more and more toward the rancher and irrigator.

On the other hand, many of the landowners themselves recognized the need to improve the water resources. State legislation created the Governor's Watershed Enhancement Board (GWEB). This board provided grants to approved applicants for watershed improvements that could be showcased to encourage increased

management and educate the public about watershed and riparian improvements. Landowners aware of the problems and local elected officials from the Soil and Water Conservation Districts and county governments began applying for funds through GWEB and other programs to address the problems.

Despite these positive steps, polarization between water interest groups was increasing. In 1989, the Columbia-Blue Mountain Resource Conservation and Development (RC&D) Council formed an ad hoc group to discuss the needs to address water resource concerns. (Columbia-Blue Mountain RC&D is a nonprofit corporation composed of Soil and Water Conservation Districts, Port Commissions, and County Governments within a five-county area in East Central Oregon.) The work group identified several problems that not only propagated polarization, but were detrimental to solving water resources issues:

- A lack of understanding by statewide public water resource interest groups of local water problems.
- A lack of concern for the effects of regulation and court decisions on the social and economic needs of local communities.
- The need to bring all interest groups to the table to communicate their concerns.
- A lack of trust between interest groups.
- The lack of knowledge throughout the state that local people and individuals are implementing projects to improve water resources.
- A trend for continued polarization of groups and the trend to resolve water management problems by the courts, which is inefficient and creates a win-lose situation.
- The acceptance that fish issues and other water resources concerns are real and that positive cooperative efforts are needed to resolve the problems.

With these things in mind, the Columbia-Blue Mountain RC&D Council determined there was a need to bring all water interest groups together to discuss these issues and others. The trend for polarization needed to be abated. In order to have any chance of success, this idea had to be sold to key decision makers of diverse water interest groups throughout the state. The idea came from the ad hoc group made up largely of landowners, farmers, ranchers, and locally elected officials. It was contrary to most ideas for statewide action that usually come through agencies, legislators, or powerful political action committees. In addition, the problems listed did not focus only on the resource problems, but were largely social concerns. Water resource agencies and interest groups that focused on the resource concerns were not accustomed to working on these issues.

Nevertheless, virtually all interest groups and agencies recognized the need and acknowledged the importance of addressing the problems resulting from confrontation. They realized a better way must be found to promote communication and cooperation and improve trust. State legislators within the five-county RC&D area were briefed on the concept and gave their support to the effort. A grant was obtained from the Oregon Community Foundation, and the Oregon Water Resources Department joined the planning effort. Additional funds were provided by the USDA Soil Conservation Service and the U.S. Bureau of Reclamation.

The Columbia-Blue Mountain RC&D Council set up an organizational meeting. In May of 1991, during the state legislative session, various interest groups met to discuss setting up a program that promoted cooperative problem solving efforts. Groups involved included state and federal agencies, livestock owners, irrigators, industrial water users, tribal representatives, environmental groups, local elected officials, and fish and wildlife groups. The Governor's office was also represented.

This group began the process of identifying communication problems. It was the first step in demonstrating that groups with different water resource objectives could work together.

The group then began planning the Oregon Watershed Forum, with three main objectives involving the mobilization of a broader public to achieve:

1. Interrelated watershed planning and management.
2. Cooperation on win-win solutions for the enhancement of water resources.
3. Participation at the local level in watershed management.

The group set up a steering committee that contained a variety of interest groups, agency personnel, and tribal representation to plan the forum.

A resource consultant helped the steering committee work through the process to plan the forum. The consultant also provided facilitators whose help was crucial to the effort. In addition, professional help was needed during the forum itself and for writing the final report. The agenda was finalized and the forum itself was held in March 1992 on the Oregon coast.

The steering committee decided to feature eight watershed problem-solving efforts by grass-roots organizations that included various interest groups. These groups were asked to focus their presentations on how and why they formed, rather than their accomplishments. Watershed case studies that were featured included entire basin areas and smaller sub-watersheds where locally initiated problem-solving activities were under way.

Some of the featured case studies were in the very early stage of identifying issues and organizing appropriate working groups. Other case studies were further along in their planning and had achieved some results. Still other case studies had a well-defined planning process and had accomplished several notable tasks, including the acquisition of staff and securing funds for water resource construction projects.

The issues addressed in the case studies varied from an exclusive focus on water quality, to an emphasis on satisfying Indian treaty rights, to more "general purpose" programs that were designed for overall watershed improvement.

The descriptions of organizational structure of the watershed management efforts also varied. In one watershed, for example, the organizational structure is based on the jurisdictional boundaries of the counties, which have very little relationship to the watershed boundaries. The other groups, however, have tried to organize around watershed boundaries, which may or may not resemble jurisdictional boundaries. Some of the case studies were driven by municipal interests while others were driven by rural concerns. Finally, some of the watershed management efforts are linked directly with existing decision-making authorities, such as county governments, while other efforts are independent.

The watershed management case studies presented at the Oregon Watershed Forum also had different origins. While some of the efforts originated from legislative mandates to address water quantity and/or quality problems, many originated from grassroots-oriented planning processes. Still others emerged in response to some threat, such as litigation.

From the case study discussions, 10 principles to achieve success were identified. These items are taken directly from the report from the Oregon Watershed Forum titled *Improving Local Efforts to Resolve Watershed Management Problems.*

1. *Organize around a problem or a threat.* Without an identifiable problem or the threat of a problem or dispute, it is very difficult to motivate individuals and groups. Several of the watershed management case studies emphasized this principle. They also emphasized how important it is to start on some small, identifiable problem; to achieve some success; and then to build on that success.
2. *Include all affected interests.* To be successful, any effort to resolve local watershed management problems must include all affected interests—including those with a responsibility to implement any proposed solutions and those who may seriously oppose any proposed solution. The affected interests must be involved as early as possible. They must also be motivated by a feeling or perception that they are likely to achieve something out of a collaborative process that they cannot get elsewhere. The participants must be willing to give and take, not point fingers.
3. *Identify a leadership group.* Every successful watershed management effort has been driven by a small group of highly motivated and talented individuals. Without such a committed group it is very difficult, if not impossible, to keep the momentum of a collaborative problem-solving process going. In many cases, it may be possible to address watershed management issues within existing community-based organizations, such as land use advisory committees or local commissions. This can save time and reduce the amount of frustration associated with organizing a watershed management group.
4. *Create local ownership.* Several of the case studies and participants made a clear distinction between

local participation and local ownership. Local interests must not only have an opportunity to participate in watershed planning and management, but also must be allowed to develop some "ownership" in the process and the solutions. This local ownership significantly increases the likelihood that recommendations will be supported and implemented. Successful watershed management efforts must also provide ample opportunities for public information, education, and involvement.

5. *Develop an adequate data base.* One of the common frustrations was the difficulty of developing an adequate data base. Most agreed that some type of joint data base, created by all the participants, was the most efficient way to gather relevant information. A joint data base also helps prevent disputes over technical information. However, most also agreed that the required information does not always exist. The case studies suggested that one of the most important roles that local and state government agencies can play is to collect, analyze, and manage technical information for each watershed.
6. *Seek consensus solutions.* Most of the watershed management efforts provided an effective forum to seek consensus, which differs from other forms of decision making, such as decision by majority rule (voting) or decision by an authority (legislative, administrative, or judicial body). These other modes of decision making typically result in winners and losers, whereas decision making by consensus seeks to find a common solution that can satisfy most of the needs of all parties. Consensus means that all parties agree to the decision, or perhaps more accurately, no party substantively disagrees with the decision. Most major decisions that a watershed management group will face cover a set of issues or items. Any member's support on an item-by-item basis may vary from enthusiastic to "willing to live with," but it is essential that each member agree to the decision as a package. In other words, the participants may not agree with all aspects of a decision, but the overall level of support from each member to the decision as a whole is sufficient to achieve consensus.
7. *Be patient and persevere.* Another principle echoed by many case studies and commentators was the need to be patient and persevere. Resolving local watershed problems is technically complex and typically involves multiple interests and jurisdictions. It takes time to build trust and understanding among the participants, to collect and analyze information, and to seek solutions that are acceptable to all affected interests. Individuals and groups trying to resolve local watershed problems need to adapt their vision of success to a realistic, typically long-term time horizon. However, they must also be aware of the lack of patience on the part of external groups. These groups may not fully understand the complexity of issues, and often turn to their legislators to develop remedies that are then imposed throughout the state or Nation.
8. *Monitor and evaluate results.* Resolving watershed management problems is a dynamic process. It never ends. Once a problem has been identified and a solution agreed to, that solution needs to be implemented, monitored, and continuously evaluated. By monitoring and evaluating implementation, the participants will learn more about the watershed and the efficacy of their initial solution. On the basis of on this new information, the participants should then redefine the problem and appropriately adapt their management strategies. By adopting this type of perspective, the participants in a particular watershed do not develop "the" plan for all time, but rely on "living documents" that guide their actions and adapt to evolving experiences.
9. *Provide an ongoing forum.* Since the management of watersheds does not end with the publication of a plan, many of the case studies suggested that it is important to provide an ongoing forum for communication, cooperation, and collaborative problem solving. This forum does not need to be mandated by the

legislature, the state government, the county, or some other formal body. The most important ingredient to maintain the viability and effectiveness of local watershed groups over time is the commitment of individuals and groups living in the watershed. Without this commitment at the local level it is very difficult, if not impossible, to resolve watershed management problems effectively and efficiently.

10. *Establish a link with existing decision-making processes.* Several of the watershed management efforts presented in the case studies were initiated by local citizens. These efforts were not part of any formal government agency or decision-making process. However, most of the case studies suggested that it is very important to be closely linked to existing, more formal decision-making processes. One way to do this, as mentioned above, is to involve, from the beginning, representatives from decision-making, funding, and resource management entities—including Congress, the state legislature, and state, federal, and tribal governments. By creating these links as early as possible in the problem-solving process, the likelihood of successful implementation is significantly increased.

During the forum, lessons learned by groups trying to solve watershed problems at the local level were discussed. These are too numerous to list here but covered objectives, planning, decision making, solutions, and process. (See report *Improving Local Efforts to Resolve Watershed Management Problems.*)

Five separate work groups provided interesting insights into difficulties to resolve watershed problems at the local level. Each group responded to the following questions:

- What are the major obstacles to resolving watershed problems at the local level?
- What specific steps can be taken, beyond this forum, to improve watershed management at the local level?

This effort produced positive results for local people trying to resolve watershed problems. It brought numerous groups together that were acquainted with one another but usually in an adversarial manner. These groups were able to interact in group sessions and identify their frustrations in working together. Through the 2-day program, they were able to get to know one another and began to develop the trust that is so desperately needed to work together. Groups that had only tried to meet their objectives through rules and regulations saw eight case studies where local people are taking the initiative to solve problems by cooperative efforts.

The result of the forum exceeded the expectations of the sponsors and the steering committee. Recommendations from the forum were taken to the Oregon Strategic Water Management Group (SWMG). This organization was formed through legislation and is composed of the state natural resources agencies. Federal agencies are advisory to SWMG, which is responsible for coordination of water planning activities within Oregon. SWMG is chaired by the Governor's assistant for natural resources. SWMG utilized the Oregon Watershed Forum information as their main tool in developing a water policy statement. Legislation has been introduced to the Oregon Legislature through SWMG to develop local watershed councils that will perform many of the activities needed to develop and implement watershed management plans.

This all began as an idea of the local work group from the Columbia-Blue Mountain RC&D Area, but it could not have been possible without many other groups creating a common vision.

Complicated Questions, Creative Solutions

Frank Gaffney, Project Director
Northwest Renewable Resources Center, Seattle, WA

My name is Frank Gaffney and I am a Project Director with the Northwest Renewable Resources Center in Seattle, Washington. The Center is a 9-year-old not-for-profit organization that provides mediation and facilitation services on matters of public policy or natural resource management. Our work is conducted primarily in the region made up of Washington, Oregon, Idaho, and Alaska, but occasionally goes beyond to other areas.

The Center has a volunteer Board of Directors made up of those who would normally come into conflict over natural resources. For example, my board includes industry executives, leaders of environmental groups, local government officials, and the chairmen of Indian tribes. The board must approve all of the projects that we take on.

I'm going to talk to you today about the process of developing watershed management plans and the subject of natural resource conflict in general.

The Nature of Watersheds

As you have heard from the previous speakers and throughout this entire conference, a watershed is a place filled with resources and diversity. Maintaining this diversity in a way that is both healthy for the ecosystem and acceptable to all of those that live, work, or just recreate within the watershed boundaries is a very challenging task indeed. The issues that bring this shared utilization to a head are usually distinguished by several common characteristics.

The Nature of Conflict

Most have been marked by long-standing and often bitter controversy. In many of these cases, the battle itself has taken on a greater importance than the resources at issue. These battles have resulted in win/lose outcomes.

The people most interested in the outcome have stopped listening to one another. Many are guilty of pre-judging how their adversaries are thinking, and then taking actions accordingly. Instead of communicating about goals and needs, they attack what they presume are their opponents' positions, thus taking the debate two steps from reality.

Administrative and legislative bodies often base their decisions on the strength of the advocate, not the merit of the testimony, thereby encouraging posturing and positioning instead of candid discussion of the issues.

Many people hold the opinion that each of these conflicts is just the latest skirmish in a war that is going to go on forever. With no end in sight, there is little incentive for trust, creativity, or finding lasting solutions.

Litigation may be the answer, but it doesn't take much courage to pick up the telephone and tell your attorney to sue someone. Litigation can be very expensive, which eliminates it as an option for some; it can take years to get a decision from the courts, longer yet if appeals are made. Courts may choose to rule only on a narrow point of law and not address your issue at all, and it can take years to see change on the ground after a court decision, even if you win.

So what each person involved in a situation like this needs to do is to weigh all of their options to negotiation. If there is some other way to get to the best answer for you and your constituents, take it! If, however, the crystal ball is a little cloudier than that, making use of the collective creativity of all interests involved in a dispute can frequently provide far better answers than any one party or a court can come up with.

Convening a Group

In disputes of this type, the parties will usually be organizations and government entities.

So how do organizations and individuals involved in conflict break this chain and begin to address these issues in a cooperative fashion? As in many things, timing is crucial, but some of the following elements may act as a trigger to get things underway:

- A fact-finding or technical panel will be approaching conclusion with no clear answer on some or all of the issues.
- A legislative or regulatory entity will be about to make a decision. Intervention can be requested either before or after the public hearings. If all or most of the disputants support negotiations, they can begin.
- Litigation has been instigated and the judge or hearings officer directs the parties to try to negotiate the issue.
- Legislation to resolve an issue is so bitterly contested that neither side can muster enough support for passage

  or

  As in a case that I actually mediated, legislation is passed, not once, but twice, and then vetoed by two different governors.
- The conflict creates enough political pressure that someone with sufficient stature (conflicting parties, governor, legislature, agency) calls for negotiations.
- Finally, one party is winning most of the time, but the costs are high in effort and expense, or the long-term assessment indicates this trend will change. Predictability or long-term stability becomes more important than short-term gain.

So the first thing you need to decide is whether the parties can resolve the issues on their own or if the addition of a neutral third party will be necessary. This question is partly one of expense, but also has to do with the nature of the controversy itself, how much is at stake, and who will have the ultimate decision making authority. If there is a single agency with jurisdiction over the entire watershed, can they act as the convener/facilitator or do they need to be a party at the table actually working on solutions? It is unlikely that serving in both roles will be acceptable to all parties.

I have met many agency employees over the years who are dedicated, energetic, intelligent, and committed to finding solutions to difficult questions. Many of them serve as facilitators during public review periods, and they do an excellent job. But the *perceived* balance of power in a negotiation is crucial to its success, and anyone who can be construed to be part of the conflict will never be viewed by all sides as neutral. This is no reflection on their talents or their dedication, it is just a product of the circumstances. Whatever the decision, if you choose a third party, they must be acceptable to the representatives at the table.

The choice of who comes to the table can rest with the convener. If it's the governor, for example, he or she can determine what agencies and private parties must be included. The overriding consideration should be an evaluation of who must be party to any eventual agreement for it to be acceptable and implementable. For the government to implement any decisions, for example, do agency or legislative representatives need to be included at the table, or just consulted afterward? Will this group simply be advisory to the agency that has jurisdiction, or will that agency participate and move forward with a group consensus? Will implementation require a public review and adoption process? Issues like these must be decided up-front so that all parties are clear on the type of process they are being asked to join.

I mentioned earlier that the parties at the table will most likely be representing agencies or organizations. Because of this, each of the parties should describe their internal decision making process to the others at the outset. If agreements at the table must be taken back to constituents for ratification, these individual processes may be quite different from one another and take

varying lengths of time. You don't want any surprises at the end, so discuss this thoroughly in the beginning.

If you are going to use a consensus process, know what that means. In short, it means that votes will not be taken. All parties must agree, or in other words, each party has veto power. Obviously, this type of approach will take longer, but if successful, it carries a tremendous amount of weight with it at the end.

I cannot overestimate the importance of finalizing these procedural matters at the beginning. One of these efforts can fail just as easily for bad process as it can for difficult substance and once a difficult issue is facing the group, it is not the time to create a process to handle it. I know the process part of these projects is boring to most. People want to wade into the issues that divide them and thrash them out.

The process decisions should be documented into groundrules or protocols and distributed to everyone at the table so they can refer to them later.

After the process decisions are out of the way, it is usually helpful to have a period of briefings or joint education. If you recall the level of dysfunction that I discussed earlier, people are often quite misinformed about the needs and goals of others. It is critical that those goals and desired outcomes are presented in an atmosphere where people are inclined to listen for perhaps the first time. A facilitator can be quite helpful in organizing the issues in a fashion that makes it easier to package solutions to related problems.

In environmental or natural resource issues, and especially in watersheds, everything is connected to everything else. For this reason it is often helpful to look at all the issues as a package. While you may have 10 issues that need to be resolved and you address them one at a time, no one has a deal until you've addressed them all and can view any agreement as a package. Since no one party is likely to get everything they want on every issue, each party has to consider the cumulative gain possible once all outstanding issues have been settled. Plus, you have the advantage of the parties having to give back any gains on individual issues if the whole package is rejected. It encourages people to stick it out until the end.

If the parties can agree, it is frequently helpful to view a problem for one as a problem for all in the context of developing a watershed plan. It forces each of them to work as hard on solutions for everyone's issues as they do on their own. It also makes an agreement that much stronger.

I guess the final point I want to make is that every individual agreement on an issue must be made with implementation in mind. As difficult as the negotiations are, and they take a tremendous amount of time and energy, implementation is going to be harder. For this reason, everyone must be thinking about how various parts of the agreement will be implemented. Will it require public funding to make it happen? Where will that come from? Will it require a change in statute? How will that be accomplished? If the baseline information you need to make the decision is not available, how will it be gathered, by whom and when?

I'm also a big fan of making agreements that don't last forever. Things change, and people need to be able to adapt to new information and changes on the ground. It may be that a big part of the agreement will depend on an ongoing process of meetings with a major review scheduled in three or five years or whenever the group feels is appropriate. In addition, people need to come back together and recommit to each other after implementation has begun. While the actual negotiators may be quite clear on the intent of this new policy, the people out on the ground are going to have to make it work and they will still be operating under the rules of the old relationships. As I said, implementation is difficult and it almost never occurs without a hitch.

I don't mean to say that it is hopeless. People have done this quite successfully all over the country.

Looking at the way we have managed resources historically and considering approaching these issues in a watershed management fashion, I am reminded of a Winston Churchill quote. Many years ago Churchill was asked about the wishy-washiness of the United States over getting into World War II. He replied, "Don't worry about the Americans, in the end they will do what's right, after exhausting all other alternatives."

Thank you for your attention, and the panel now would be happy to answer your questions.

Consensual Decision Making for Watershed Management

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C. Mark Dunning, Ph.D., Program Analysis Division Chief*
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Different priorities, different views about the use of resources, questions about jurisdiction, overlapping authority, and other considerations have made water resource management ripe for conflicts, often convoluted and litigious. Legislation, such as the National Environmental Policy Act, has given public interest groups the legal standing to contest agency decision making and to intervene in water resource management. Consequently, a need has developed to make resource management decisions that overcome the ensuing animosity and resulting adversarial positions.

The use of Alternative Dispute Resolution (ADR) procedures is emerging as a viable approach to address water resources issues (Bingham, 1985). These are consensual decision-making processes that encourage separating the people from the problem; focusing on interests, not position; inventing options for mutual gain; and using objective criteria (Fisher et al., 1992).

When parties in a conflict engage in these behaviors, resolution of conflicts are highly likely. However, it has often been found that parties in conflicts have a great reluctance to begin such cooperative procedures; parties' resistance to actually beginning an ADR process has proved to be a difficult obstacle to overcome. However, once parties have overcome this barrier, they can often engage in cooperative, decision-making activity and reach mutually agreeable outcomes.

The U.S. Army Corps of Engineers (COE) has been interested in implementing consensual decision making and interest-based negotiation for the past two decades. The Institute for Water Resources (IWR) began encouraging public participation in decision making over the use of water resources in the early 1970s. Ten years later, in 1984, the Office of Chief Counsel began using the mini-trial as a means to cut losses in time and expense in construction claims disputes and, since 1988, has funded a program on ADR implemented by IWR.

Through the ADR Program at IWR, a model has been developed for joint training as a first step in bringing parties "to the table" for engaging in consensual decision making. Of three applications of this model, all have been successful in helping parties to develop a process for intervention or conflict resolution.

This paper includes an outline of the model; a description of the process; a description of the dispute; a description of third-party entry and intervention opportunities; termination of the intervention and follow-up; and an analysis of the success of the training and intervention.

This case study analyzes the use of joint training in one application for bringing parties "to the table" and takes the perspective of the facilitator/mediator, who is the ADR Program Manager at IWR. The model used for this training was developed solely by her, under the supervision of the Chief of the Program Analysis Division.

Rationale for Joint Training

Previous cases have suggested that water resources decision-making environments in conflicts are most productive for

*The views expressed in this paper are those of the authors and do not necessarily reflect those of the U.S. Army Corps of Engineers.

rendering solutions when there are incentives for parties to "come to the table"; there are opportunities to exchange information and negotiate over interests; and there is a credible, impartial third party to assist in the resolution efforts (Dunning, 1987). Implementing a means to provide for the above factors is extremely pertinent because the tendencies of parties in any conflict are to withdraw from one another; reduce communication with each other and withhold information; misperceive each others' actions by stereotyping, projecting, and mirror-imaging; move toward extreme positions; and take on adversarial roles. (See, for example, Wehr 1979.)

Joint training can be used as a means to relieve the above tendencies and to more easily allow third-party entry for ADR by bringing parties face-to-face, initiating communication, reducing stereotypical images, and softening polarized positions. Joint training is essentially a communication process wherein parties can *learn* of the others' perspectives and *teach* each other about their interests and needs. Conditions that favor third-party intervention include a complex, drawn-out conflict; a deadlock of the parties over their own efforts for resolution; continuation of the conflict as an exacerbating factor; and a level of cooperation among the parties (Bercovitch, 1984).

A Joint Training Model

The model provides training to the participants in the following elements of ADR application:

- Characteristics and benefits of ADR.
- Principles of interest-based negotiation.
- Types of conflict and overview of ADR processes.
- Conflict assessment.
- Case study analysis.
- ADR principles applied to this conflict.
- Next steps.

The training includes exercises in interest-based negotiation, identifying parties, and conflict analysis.

Case Study of a Watershed Management Dispute

The case being presented here came to the attention of IWR on May 22, 1992, when the Planning Division of the Kansas City District, COE asked for help in resolving a dispute over the alignment of a levee in a flood control project. The City of Kansas City provided funding and sponsorship for this project.

Background to the Dispute

This dispute had developed over the placement of a levee on the Big Blue Battlefield on the banks of the Blue River within what is now the city limits of Kansas City, MO. The specific issue was the City of Kansas City's use of eminent domain through a Civil War battlefield. Byram's Ford Industrial Park is now located on the west bank, the site of the proposed levee and most of the battle's action. The battlefield on the east bank has been less affected by modern development (Ziegler).

The U.S. Department of the Interior placed the Byram's Ford Historic District on the National Register of Historic Places (NRHP) on October 16, 1989 (Civil War Round Table (CWRT) pamphlet). The Byram's Ford Historic District includes the Byram's Ford Site of 12 acres and the Byram's Ford Road Site of 5 acres (Ziegler).

Actual construction of The Blue River Channel Project for flood control commenced in 1983. For ease of construction administration, construction was divided into three stages: Stages One and Two, the lower portions of the project, had been under construction while plans and specifications for Stage Three were under development. To keep the project on schedule, plans and specs for Stage Three had to be finalized so that the City of Kansas City could acquire the necessary rights-of-way by July 1993.

The Dispute Develops

The Civil War Round Table (CWRT) is a Kansas City organization "dedicated to the study and preservation of our Civil War heritage" and has been the active force in maintaining and preserving the battlefield (CWRT pamphlet). After the CWRT had shown, in 1983, that Byram's Ford still existed, the Kansas City District committed to protecting the site. To effect this protection, the flood control design was altered so that a grade control structure would be moved from its original site downstream from the Ford. The proposed grade control structure would have affected approximately

8 acres of the battlefield to the north of the Byram's Ford NRHP site.

The primary disagreement was over the placement of a levee to protect the Byram's Ford Industrial Park from flood damage. Of four levee placements presented, CWRT gave one a positive response; but the CWRT indicated that it preferred no levee at all. From the CWRT's perspective, any levee would have been viewed as another intrusion into the battlefield. The placement most acceptable ran east-west, parallel to the movement of the battle, and avoided one of the most heavily contested battle sites. The City of Kansas City had chosen another levee alignment that ran in a north-south direction across the battlefield and along the riverbank. The City considered this a compromise. From the Kansas City perspective, this alignment would have protected most of the buildings in the industrial district and, as it was set far back, would not have any effects on Byram's Ford. The CWRT had objected to this levee placement because it would have crossed the main battle area. A concern for the other parties was that the CWRT would protest the location of the grade control structure if there were not a satisfactory levee alignment. CWRT's approval was felt to be crucial for timely completion of the project (Ziegler).

The Kansas City District was concerned that the disagreement would affect its overall project construction schedule and that there would be adverse public reaction if the CWRT used political pressure to gain support for protection of the site. At the request of the CWRT, several public officials visited Kansas City—the Secretary of the Interior, the Chief Historian of the National Park Service, the Director of the Missouri Department of Natural Resources, the State Historic Preservation Officer of Missouri, and local Congressman Alan Wheat.

The First Intervention Opportunity

Kansas City District wanted to attempt resolution of this dispute without resorting to litigation, but the CWRT was reluctant to agree. The City of Kansas City, although taking a fixed position at that time, had indicated that it would participate in a consensual process. The business and property owners had not yet become a cohesive group with clearly delineated interests of its own. Lack of knowledge about ADR and consensual processes limited the scope of the District and the other parties in developing a nonlitigative solution.

Kansas City District initially asked IWR for a facilitator to help the parties become comfortable interacting. IWR agreed to send a professional in dispute resolution to meet with the District officials and representatives of the other parties. The Chairman of CWRT's Board of Directors had arranged for the board members and the officers of CWRT to meet with the District's Chief of Civil Works Project Management Branch and the intervener at the home of the secretary of the CWRT on the evening of June 17, 1992. The intervener had been asked to offer a brief overview of ADR, especially in reference to a public policy dispute.

The intervener spoke very briefly and informally on consensus-building as a component of ADR, positional bargaining versus interest-based negotiation, and the application of ADR in public policy disputes. She emphasized that we all use the principles of ADR in everyday business and personal life and pointed out to the group that they were at that moment engaged in the first step in a consensual process—looking at the dispute as a joint problem, listening to each other, and being open and honest about needs and expectations. The CWRT group was cautious but interested. After concerned hesitation, the CWRT, by unanimous decision, agreed to participate in IWR's 1-day joint training on ADR processes and application. The City of Kansas City, the Kansas City District, and the CWRT cooperated in arranging for that training.

The Second Intervention—Joint Training

On July 29, 1992, the intervener conducted a 4 1/2-hour ADR training/workshop at the District headquarters. The District invited representatives from the CWRT, the City of Kansas City, and the Byram's Ford Industrial Park Association to a joint training on the principles of ADR. In addition to the representatives from the four principal parties, the 21 persons attending the meeting included officials from the National Park Service, the Fish and Wildlife Service, the Missouri Department of Natural Resources, and the Missouri State Historic Preservation Office.

After welcome, introductions, review of session objectives, and agenda review, the rest of the agenda followed the model previously described. The last exercise was an analysis of the conflict at hand. In that exercise the attendees identified all parties, primary and secondary; interests; issues; a list of obstacles to resolution; and next steps. During the discussion of the next steps, two of the principal parties—the CWRT and the City of Kansas City—moved away from fixed positions. The City of Kansas City declared an interest in resolving the problem by developing a "creative process," and the CWRT moved from a position of no levee to accepting a levee but wanting a say in its placement.

The principal parties agreed to meet again, as soon as possible, to identify a process for coming to consensus on the levee placement. The secondary parties were happy to see a resolution in sight and felt no necessity to be there.

Another Intervention Opportunity—Process Identification

On August 21, 1992, the intervener returned to Kansas City to help the parties identify a process for resolving their dispute and to give direction in selecting a neutral third party. After the welcome, introductions, a brief review of where the parties stood, and a presentation of the agenda for the day, a planner with the City of Kansas City indicated that they "just wanted to get on with it." The group immediately reached consensus to mediate and asked the intervener to mediate.

The initial phase of the mediation was essentially an information exchange. Each party—COE, CWRT, City of Kansas City, and Byram's Park Industrial Park Association—had an opportunity to present its requests. The Corps was essentially neutral. The COE's project manager, using maps and photographs, presented the different levee alignments that had been proposed. Kansas City's representative presented the City's position, also, as being neutral—it just wanted the property owners and the CWRT to come to an agreement. The CWRT presented its overall plan for the development of the Big Blue Battlefield as a historical site, and its perceived need for open space on the site of the industrial park, i.e., a levee placement *behind* the industrial park. The property owners presented a surprise—after presenting a neutral position at the joint training, they expressed a desire for a levee placement to protect a major property owner's site.

After discussion of the issues and a seeming impasse, the parties caucused in the middle of the afternoon. Upon returning to the table, further discussion revealed some common points for settlement; and the basic elements for an agreement were realized by the end of the afternoon when the intervener listed on the board common elements that she was hearing. This list turned out to be the basis for the outline of a written settlement agreement and was initialed by the party representatives. The parties determined that the legal division of the Kansas City District would write the draft agreement and established a schedule for producing the product, for its review by the parties, and for a meeting of all parties to develop a final agreement document. The parties asked the intervener to attend that meeting to help in developing a final agreement.

Termination of the Intervention

On September 24, 1992, the intervener returned to Kansas City to mediate for the four principal parties to the levee placement dispute over the terms of a final draft of a settlement agreement. The session commenced at 9:00 am and adjourned at approximately 12:30 pm upon the signing of the final draft agreement. The Kansas City, MO, City Council and the CWRT Board gave the agreement final approval, and the four principal parties signed the settlement document on December 1, 1992.

Analysis and Summary

The parties' desire to cooperate and the availability of a forum to "come to the table" with an impartial third party for information exchange enabled the resolution of this water resource management dispute.

The dispute met conditions for favorable third-party intervention: it had been ongoing for several years; the parties had expressed fixed positions to the intervener at the initial meeting with her; continuing the conflict while waiting for waivers and reports would have further distanced the parties and exacerbated the situation; and the willingness of the parties to come to

the table for joint training indicated a high level of cooperation among the parties. The only obstacle was the lack of a suitable forum to begin cooperatively solving the problem.

The joint training gave the parties the "safe" forum to begin the process of cooperation in that the training venue provided the opportunity for parties to begin the exchange of information and to interact with each other in a nonthreatening situation. The ADR principles presented during the training provided the parties with the tools to analyze the issues, interests, parties, and obstacles to effect resolution for their own dispute.

Our experience suggests that joint training of parties in water resources management disputes is a viable option for starting the process of consensual decision making. Through exercises and analysis, parties can learn the skills to recognize a common interest in nonjudicial resolution and can identify areas where other, indivi-dual party interests can often overlap. By creating a forum conducive to clear communication, joint training can engage parties in conflicts to overcome the difficult first step of "coming to the table." Consensual decision making can begin.

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Streams of Dreams: If You Restore Them, Fish and Wildlife Will Come

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Washington's Olympic Peninsula is a unique blend of marine climate, lush vegetation and mountainous terrain. Snowcapped peaks spawn rivers filled with salmon and steelhead of legendary size. Its towering forests encircle a span of biological diversity so wide it has been designated a world biosphere reserve.

Tragically, much of the area has been scarred by decades of past management activities. This mismanagement has resulted in damaged ecosystems and declining fish and wildlife populations. In an area where annual rainfall often exceeds 100 inches, entire watersheds are at risk from earlier land use practices. This combination of land use practices, heavy rainfall, and steep slopes has produced catastrophic results. On one forest district alone, over 35,000 earth giveaways have already been identified.

Anadromous fish, returning to Olympic Peninsula streams, face over 400 known blockages to upstream passage, according to a Washington Department of Fisheries study. Forty-one stocks of Washington Coast/Puget Sound area anadromous fish have been identified by the American Fisheries Society as at risk of extinction. Seventeen of these stocks occur in streams flowing through the Olympic National Forest alone. Four Olympic Peninsula wildlife species are currently listed as threatened or endangered under the Federal Endangered Species Act, and another nine are candidates for listing, as are five native plant species.

The damaged ecosystems on which these and other species depend are criss-crossed with a web of private, state, and federal ownerships. To be effective, efforts to avert future Endangered Species Act listings and possible adverse social and economic impacts must face these problems on an ecosystem-wide scale. To proactively address these needs, the U.S. Fish and Wildlife Service (FWS) and the Olympic National Forest have joined with other natural resource agencies to form the Olympic Peninsula Watershed Management and Restoration Alliance. Using methods already proven by the enormously successful Washington Ecosystems Conservation Program, the alliance is a partnership of state, federal, tribal, and private landowners that sets the stage for future interagency partnerships.

Recognizing that over half of Washington, including most of the remaining fish and wildlife habitat, is in private ownership, the Olympia Ecological Services Office of the FWS and the Washington Department of Wildlife formed the Washington Ecosystems Conservation Program as a partnership to share costs, knowledge, and expertise to enhance and improve fish and wildlife habitat on privately-owned agricultural lands. Since the program began in 1991, 80 projects have been completed, affecting 2,835 acres of wetlands, 119 miles of streambank and riparian habitat, and improving habitat on 12,940 upland acres. In one ecosystem alone, its activities have affected over 57 miles of streambed, improving water quality by over 70 percent and removing the need for five sewage treatment plants, a savings of over $100 million. Contracts with 182 cooperators have opened another 258,500 acres of private land to resource and public access management. Thirty-four more projects are currently under construction or in advanced planning stages. These projects will

improve or restore habitat functions and values on 780 acres of wetlands and 6,720 acres of uplands.

Taking a page from the Ecosystems Conservation Program's success, the Olympic Peninsula Ecosystems Management and Restoration Alliance is employing similar techniques across federal, state, tribal, and private lands on the Olympic Peninsula. Cooperative agreements and partnerships between state and federal agencies, native American tribes, and local landowners will provide for a combination of funding assistance, technical support, and in-kind services. Working with local groups like the Hood Canal Coordinating Council will ensure effective utilization of resources. Restoration activities will include hillside stabilization and erosion control, road removal, and revegetation with native species. Enhancement of riparian corridors and stream restoration for improved fish and wildlife habitat will also be undertaken. Experienced operators familiar with local conditions will help restore natural conditions, speeding resumption of natural processes. Timber workers and equipment already displaced by changes in the timber industry are natural candidates for these restoration jobs. It is estimated that between FWS and the Olympic National Forest, 850 displaced workers could be employed on restoration work for the next 10 years. By combining vital watershed management and restoration work with efforts to alleviate social and economic impacts of past management activities, the Olympic Peninsula Watershed Management and Restoration Alliance can provide local employment opportunities.

The Olympic Peninsula Watershed Management and Restoration Alliance will also improve local fish and wildlife habitat and populations, resulting in improved recreational and commercial opportunities while decreasing the chances of future endangered species act listings and their potentially adverse effects. Soil productivity will be increased, resulting in better and healthier timber stands and ensuring valuable natural resources for the 21st century. Recovery will depend on leadership, cooperation, financial investment, and long-term commitment. But if we restore the habitat, the fish, wildlife—and the future—will come.

Watershed Restoration Through Integrated Resource Management on Public and Private Rangelands

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Background

The shortgrass rangelands found in the western United States are generally harsh ecosystems. Typical rainfall ranges from 25-65 cm, precipitation patterns are erratic and evaporation losses high, temperatures are often extreme, the topography rough, and the soils can be shallow and rocky. Careful management of these areas is essential if they are to maintain sustained production or recover from past land management mistakes (Stoddart et al., 1975). The USDA estimates that 85 percent of the nation's rangeland is in fair to poor condition (Chaney et al., 1990). Many of these watersheds contribute massive loads of sediment, washed from the land surface or scoured from eroding gullies and streambanks, to the streams and rivers that drain them. The New Mexico Environment Department reports that 95 percent of the state's surface water is impacted by nonpoint source pollution (NMED, 1990) and that turbidity is one of the major causes of use impairment in these waters (NMED, 1988). Reports by early surveyors, naturalists, and trappers detail the abundance of grass and clear clean water found on these watersheds (Leopold, 1933/1991), a sharp contrast to the conditions seen today.

Many factors have contributed to the drastic changes that can be seen in the rangeland watersheds of the western United States, but most range management professionals agree that the heavy stocking rates and the continuous grazing practiced by stockmen at end of the 1800s, followed later by the suppression of fire, are the leading causes of these changes. Historians note that the 1860s marked the beginning of large-scale western livestock production. High market prices and abundant grasslands encouraged speculation and lax management (Stoddard et al., 1975). H.L. Bently and E.O. Wooten, early agricultural agents in Texas and New Mexico, described the situation, "In a short time every acre of grass was stocked beyond its fullest capacity . . . . The grasses were entirely consumed; their very roots were trampled into the dust and destroyed" (Bently, 1898). "The stockman could not protect the range from himself, because any improvement of his range was only an inducement for someone else to bring stock in upon it; so he put the extra stock on himself" (Wooten, 1908). As a result, native grasses were replaced by sagebrush, mesquite, juniper, and other invading brush species that were less suited for holding soil in place (Chaney et al., 1990) and more efficient at water extraction (Stoddart et al., 1975). Topsoil, which requires thousands of years to develop in harsh ecosystems (Brady, 1974), washed away; gullies formed from unchecked, concentrated runoff; streambanks eroded and downcut; water tables lowered; and perennial streams became intermittent or dry (Chaney et al., 1990; Platts, 1990).

The ability of the land to recover from these effects has been greatly reduced because the entire ecosystem had been so radically altered. The harshness of the environ-

ment contributes to the difficulty in reestablishing the climax or the highest ecological condition of the range. As a result, simple manipulation of a single range management factor, such as reducing livestock numbers, is not sufficient to result in significant environmental improvement (DeBano and Schmidt, 1989). These systems will take thousands of years to recover by themselves. Direct actions aimed at total watershed rehabilitation and applied in a holistic and integrated system are necessary to ensure the restoration of western watersheds and associated natural resources of water, timber, grass, wildlife, and fisheries (Platts 1990). This type of integrated or holistic resource management has been successfully demonstrated on the Carrizo Valley Ranch by owner and operator Sid Goodloe for more than 30 years. He describes his experiences as follows:

Integrated Resource Management on Private Lands

There are many definitions of Integrated Resource Management (IRM) but I like to define it as the integration of all components—economic, human, and environmental—into a synergistic, comprehensive plan that allows management for long-term sustainability rather than short-term production. This type of management is essential for protecting valuable natural resources found in our western watersheds, but is also an essential management tool for protecting the entire planet. There are many examples of poor natural resource management in every state of the US and in every country in the world; clearly, we are now charged with the responsibility of not only managing the resources under our jurisdiction in an integrated manner, but also informing politicians and populations everywhere that we are no longer in the pioneering and unplanned development mode. We have reached the point that resource interrelationships must be recognized and development planned accordingly. Pressing needs of growing populations must be met, but not at the expense of ecosystem sustainability.

Initial Actions

I began IRM as a survival mechanism; I needed to use all of the resources available on my ranch in a manner that provided for my family and guaranteed sustained or improved production of salable end products. I began to inventory my resources, isolate problems, and set goals based upon my experiences with range management in Kenya and the United States. My ranch is located in the South Central Mountains of New Mexico at about 7000 ft. elevation. Average annual precipitation is about 46 cm (18 inches), one-half of which falls as snow. The soils range from gravelly hillsides to clay and clay loam bottoms. Watercourses on the ranch were actively eroded and brush infestation flourished when I purchased the property. My most demanding problem was the homogeneous vegetative composition and low herbage production. The major grass found was an almost pure, tightly packed turf of bluegramma that grew very little because of its sod-bound condition. A major portion of the ranch had scattered to thick stands of pinon-juniper of even aged populations. Areas between the trees as well as directly under the canopy were bare and subject to erosion.

I began to study the origin of this eroded, brush infested condition. I realized that year-long grazing and brush infestation was severely limiting herbage production. My initial strategies were (1) to divide the ranch into summer and winter pastures so I could at least reserve some winter grazing and (2) to begin a systematic brush control program. Although these changes were beneficial, it was not until I spent time in Rhodesia (Zimbabwe) in 1964 that I experienced first hand and began to understand the principles of Short Duration Grazing Systems in action and the dynamics of an open savannah ecosystem. I recorded my findings in a paper published in the November 1969 issue of the *Journal of Range Management,* returned to my ranch, and after installing some very low-cost fencing, put these principles into practice.

Rotational Grazing System

I divided large paddocks into much smaller ones using posts cut from timber on the ranch to support a three-wire suspension fence. Paddock division was planned according to topography, existing fences, and available water—not in the wagon wheel or grazing cell pattern often advocated. Once the rotation had become established, the cattle practically moved themselves, anticipating paddock changes. I

found that I must pay very close attention to the herbage off-take, so that graze and rest periods could be adjusted to fit the current precipitation and season of use. I also found that as the vegetative growth rate increases so should the frequency of rotation, and that rotation during the dormant season was not necessary. My initial goal now became "to produce the maximum pounds of marketable beef per hectare while improving range condition." This naive, but commendable, goal was economically impractical in a period of low beef prices, so I needed to find other profitable uses of available resources.

Additional Income Source

Fee hunting of deer and turkey became a significant income producer immediately after I built a cabin to facilitate game harvest. As a result, improved wildlife habitat and overall aesthetic quality became my secondary goal.

Return to Climax Condition as the Primary Goal

The pieces of the puzzle then began to fall into place. I realized that if fish and beaver appeared on the 600-year-old Indian petroglyphs on my place, there certainly must have been running streams where I now found only arroyos with steep banks and dry rocky bottoms. I researched 100-year-old surveyors' notes that described the terrain as an open savannah rather than an almost solid canopy of invading brush species. I realized that the invading brush, resulting from year-long grazing and 80 years of total fire suppression, was not only removing most of the moisture from the soil, but was also shutting down herbage growth, thereby causing sheet and gully erosion. I recognized that, although I had previously discounted a return to climax or near climax condition, I might be able to make economic sense out of that approach if it became my primary goal. I visualized the open savannah as it was over 100 years ago, with mixed conifers on the north slopes and the highly productive riparian areas that made up the mosaic of the Carrizo Valley.

Brush Management and Watershed Stabilization

I then began to implement a cautious return to climax in a manner that was economically justifiable in my situation. Mechanical removal of invading pinon-juniper in an area that requires 10-15 hectares per animal unit could not be justified because costs were higher than land values. However, some mechanical brush control in the better soil types was required as was erosion control (i.e., reseeding, pushing invading brush into active gullies, and building water retention dams). It was necessary to finance this using other available resources.

Selective thinning of young invaders, followed by prescribed burning and reseeding with native grass species, became the major thrust of the plan to return to a climax ecosystem. The by-products—fence posts, fuel wood, vigas, trees for landscaping, and Christmas trees—financed the plan. Another beneficial by-product was the increase in mule deer population, not only because of habitat improvement, but because ponderosa pine vigas must be cut and peeled during the winter months. This provided an adequate supply of green browse (tree tops) throughout the winter, resulting in significant (30-50 percent) increases in the fawn crop. The newly created open savannah contains 500- to 800-year-old juniper trees, scattered ponderosa pines, and is carpeted with a mix of warm and cool season grasses and forbs. I have found that because deer and turkey evolved under this type of ecosystem they seem to prefer it to the contiguous brush infested public land. This is what I call an "eco-recreation benefit." These factors sharply increased income from hunting and paid for more of the necessary mechanical rehabilitation work.

The Role of Fire

The long sought-after open savannah is now well established in the Carrizo Valley, but it must be maintained with periodic fire. Tree ring research in New Mexico indicates that, before fire suppression began, most forest areas burned at 7- to 10-year intervals (Stoddart et al., 1975). The key to the successful maintenance burn is the fuel load (as well as the climatic conditions, of course). There must be enough herbaceous material to carry a fire that is hot enough to kill brush but cool enough not to damage the beneficial species. The damaging fire in Yellowstone a few years ago demonstrated that the no-burn policy, which originated in the ecologically different European forests, was an incorrect

choice for western watersheds. Now after many years of fire suppression, similar fuel loading is evident throughout the Western United States, and has made the initial prescribed burn risky, to say the least.

Burning is quite expensive when the planning and execution of a fire are taken into consideration. It is necessary to defer grazing before the fire (to accumulate the needed litter to carry the burn) and after (to avoid damaging the range as it recovers). Timing to fit the prescription is extremely difficult. However, herbage production has doubled or even tripled where broom-snake weed was killed by fire, and oak brush produces much more palatable and nutritious browse after burning. Aro (1971) and Wright (1972) have also demonstrated this in controlled studies on demonstration plots and watershed areas.

Grazing Management

Grazing management has proven just as important as brush control on the road back to climax range condition. Using a Short Duration Grazing (SDG) System for more than 20 years, I have been able to shift my vegetative complex from a warm season monoculture to a varied population of warm and cool season grasses and legumes, complemented by an increasing variety of browse species. Other subtle changes have occurred, such as an increase in the ratio of younger plants to older plants of all species, and the disappearance of barren areas and trails. This, of course, is the result of SDG, which prescribes that you concentrate livestock in each paddock a very short time during rapid growth, and then move the livestock on, allowing plants that have been bitten enough time to rest. This allows for adequate leaf growth so that root reserves are replenished and in some cases seed is produced.

Livestock Suited to Their Environment

The pivotal economic component of my operation is the production of weaner calves, both for breeding and beef. Low-input, sustained production is my goal. It is achieved by using an animal that is fine tuned to the environment and produces a desirable, marketable product. The hostile factors in our environment are snow, cold, wind, and dry weather. A cow that can produce under these conditions must be, first of all, fertile in that environment. She should be black so that wind and snow will not cause or aggravate pink eye and cancer eye. Black, of course, absorbs as much sparse winter sunlight as is possible and black udders do not blister in spring snow storms. The animal that fulfills all these requirements is a composite breed, which I have developed through 20 years of selective breeding, called the Alpine Black—three-quarters Angus and one-quarter beef-type Brown Swiss. Just as the Zebu composites fit the Gulf Coast and southern deserts, the Alpine Black fits the western mountains of Northern America.

Tangible Benefits

The road back to climax has revealed many changes in 30 years. Water sources that were dry now have permanent running water and lush riparian areas. Wildlife is attracted to the open areas and burns. Grass production has increased dramatically and provided more carrying capacity. Weaner calf weights are now over 600 pounds because Alpine Black cattle are in sync with their environment and their habitat has improved as well. Recreation potential is greatly enhanced due to a more pleasing aesthetic atmosphere and larger wildlife populations. The future holds many opportunities for even more innovative approaches to IRM. It is almost time to bring back the beaver and turn the erosion control over to them.

Applicability of Case Study Results to Western Watersheds

The pinon-juniper complex comprises more than 63 million acres of the rangeland in the Southwest. This ecotype is a critical component of the semi-arid region. Considerable debate regarding the density of the pinon-juniper canopy in climax conditions has hindered some watershed restoration efforts. Most range conservationists agree, however, that much of the pinon-juniper found on the lower slopes has escaped it original range and modified some of the original savannah type ecosystem to a more woodland type. Work on the Goodloe ranch, especially on the lower mountain slopes with the most productive soils, has been an important test of range rehabilitation techniques during a

time when little research on this subject is ongoing.

Originally the pinon-juniper occupied a discrete ecotone in many watersheds but lack of fire and overuse by livestock have left these once stable areas in poor condition. Many, however, have a high potential for range improvement and re-vegetation. In areas where the pinon-juniper complex is in especially poor condition, range improvement can substantially reduce the erosion and sedimentation originating from these degraded areas (Stoddart et al., 1975). Some of the most informed members of the environmental community support restoration of western watersheds but question the removal of pinon and juniper vegetation from those areas where the species are the climax community. As opposed to brush removal and range reseeding on areas historically known or reasoned to be grassland, brush removal on certain areas can have the potential to increase sedimentation and erosion rather than decrease it (DeBano and Schmidt, 1989; Chaney et al., 1990). Information gained from the Carrizo Valley Ranch can be useful to managers needing to determine how far up-slope brush management efforts can be reasonably and safely completed and a sustainable system established.

Riparian areas and the water they surround are of especial consequence in arid ecosystems. These areas constitute only about 2 percent of the total western acreage yet they are among the most productive and valuable lands. These areas can strongly influence how watersheds function by influencing the timing and quality of water produced (Chaney et al., 1989; Platts, 1990). EPA (1993) has stated that one of the most effective Best Management Practices (BMPs) for improving and maintaining high quality water resources is a healthy, functioning and intact riparian area. DeBano and Schmidt (1989) have described the relationship of upland watershed condition to riparian condition and found, not surprisingly, a direct correlation between degraded upland watershed condition and degraded riparian area condition. They concluded that *adequate treatment of all critical areas in the upper watershed is necessary to provide a stable and sustainable riparian area* and is critical when attempting any riparian restoration project. Goodloe demonstrated the practical application of this principle on a smaller scale at his ranch by completing most of the upper watershed work (stabilizing gullies, removing invading brush, and re-vegetating bare ground) before being able to maintain a stable riparian area. Chaney and his coworkers (1990) and Platts (1990) found that maintenance of riparian areas, once restored, requires a different grazing strategy than upland sites. Often one of the most controversial BMPs recommended for rangeland is riparian corridor fencing that works to protect the riparian area from livestock access. Goodloe demonstrated that as long as the principle—limited and managed access—is applied, fencing is not always a required component. The key to the effective riparian protection demonstrated at Carrizo Valley Ranch was protection during the growing season if possible and rapid rotation when not.

IRM on Public Lands—Carrizo Demonstration Area

The watershed above the Carrizo Valley Ranch is part of the Smokey Bear Ranger District of the Lincoln National Forest. In 1989 the U.S. Forest Service (USFS) began a watershed restoration and demonstration project on 55,000 acres of National Forest and private land as part of the New Perspectives Initiative. The project area contains large expanses of continuous canopy pinon-juniper woodland, not only on the steep and rocky slopes where these species are the climax community, but also on the less sloping and more productive sites, that prior to the introduction of livestock in the 1800s and subsequent fire suppression supported a wide variety of native grass plants. As the range degraded, trees out-competed grass for available moisture and soon much of the productive soil beneath these dense woodland stands eroded away leaving behind an extensive and active gully system that continues to transport silt-laden water into streams and rivers (Edwards, 1990). With the urging of private landowners who for years had to contend with the deposition of millions of tons of sediment that originated on National Forest land, and who had demonstrated that watershed rehabilitation was possible on their private landholdings, a unique, cooperative watershed based project was begun. The planning team consisted not only of USFS hydrologists and other

specialists but 13 grazing permittees, three private landowners, researchers from New Mexico State University (NMSU), the New Mexico Department of Game and Fish, the New Mexico Division of Forestry and Resource Conservation, The New Mexico Range Improvement Task Force and the NMSU Cooperative Extension Service. The project focuses on soil stabilization practices, vegetation management, water resource development, vehicular travel management, and sound grazing management practices. The project's goals include control of soil erosion, stabilization of steep gully slopes, restoration of permanent riparian vegetation, and the rehabilitation of native rangelands to support a sustainable mix of native grass and woody plants. Recognizing fiscal and management limitations in so large a watershed, the planning team identified high priority treatment areas as those with unsatisfactory watershed condition and high soil productivity. The best management practices applied to the high-priority areas include small dams, gully reshaping, reestablishing native soil-protecting vegetation, thinning trees for fuel wood, and removing unwanted excess tress through mechanical means and prescribed fires.

As the result of treatments—begun in 1989—cool season native species of grass and forbs long absent from the National Forest have returned, in several drainage areas springs have begun to flow again, and a wide variety of upland and riparian wildlife species have returned making use of the increased edge areas, water supplies, and additional food sources. To date 1,550 acres of unsatisfactory condition watershed have been treated through vegetation management (mostly timber and fuel wood harvest) to increase herbaceous ground cover, 3.4 miles of gullies have been stabilized, and 4 miles of roads have been obliterated. Additionally 900 acres were treated with prescribed fire for creation of wildlife openings, two wildlife water developments were installed, and 15 acres of existing riparian area were fenced to exclude livestock. On private lands adjacent to the forest benefits have also been reported. In one area, 4,800 cubic yards of sediment from gully and sheet erosion originating on National Forest land was cleaned out of a pond. The following spring, after implementation of watershed restoration treatments on the forest, a spring that had not run for 50 years began to flow and continued to flow throughout the summer, filling the pond with clear water. The pond has now been stocked with trout and catfish. It is noteworthy that the Forest Service used on-site resources for much of the rehabilitation work and supplemented the project with funds from the sale of forest products, including 4,000 board feet of timber, 500 small and medium poles, and 2,850 cords of firewood. As an additional benefit, USFS has realized a cost saving by working directly and cooperatively with permittees, providing sufficient training to these cooperators so that Forest Service employees no longer have to mark leave trees on fuel and timber harvest areas.

Summary

Integrated resource management is the professional vernacular describing what managers do when they are in tune with efficient, sustained use of the resources that are their responsibility. If the use of one resource affects the health or production of another adversely, then the whole is diminished and economic and environmental costs are guaranteed to surface somewhere sometime. Common sense and vision provide the foundation for bringing all parts of the whole together into a comprehensive management plan. Interestingly enough, as are many things in life, it is elusive because it is so simple. Yet, if we intend long-term survival we must implement this approach in every phase of natural resource management. As watershed restoration and rehabilitation work continues, it is important to understand that there will never be sufficient government resources to treat every problem in every area. Thus, success lies in demonstrating those techniques which provide internal and self-sustaining motivation for adoption on both private and public lands

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Multiple Objectives Planning at Portland, Oregon, for the Balch Creek Watershed

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Background and Setting

The Balch Creek Watershed is a unique urban wild area, close to one of the largest urban parks (Forest Park), and within a 10-minute drive from downtown Portland (Figure 1). For the last year the City of Portland, Oregon, Bureau of Environmental Services (BES) has been preparing a multiple objectives plan for managing the storm water and related resources of the Balch Creek Watershed in Portland's West Hills. Completion of this Storm water Management Plan (SMP) is expected this summer. The watershed area is approximately 2 square miles of steeply-sloped forest land and contains small amounts of urban residential development, particularly in the southeast corner and along the ridges. At the lower end of the watershed, Balch Creek enters an 84-inch diameter pipe and flows approximately 1 mile under an industrial area before flowing into the Willamette River (Photo 1). In the piped portion, a combined sewer overflow and small amounts of additional storm water enter the pipe.

The SMP includes elements which address flood control, water quality, fish, wildlife, and recreation-education. The project includes the design and construction of an early action "pilot project" which combines a wetland to enhance water quality with a detention storage facility to reduce downstream flooding.

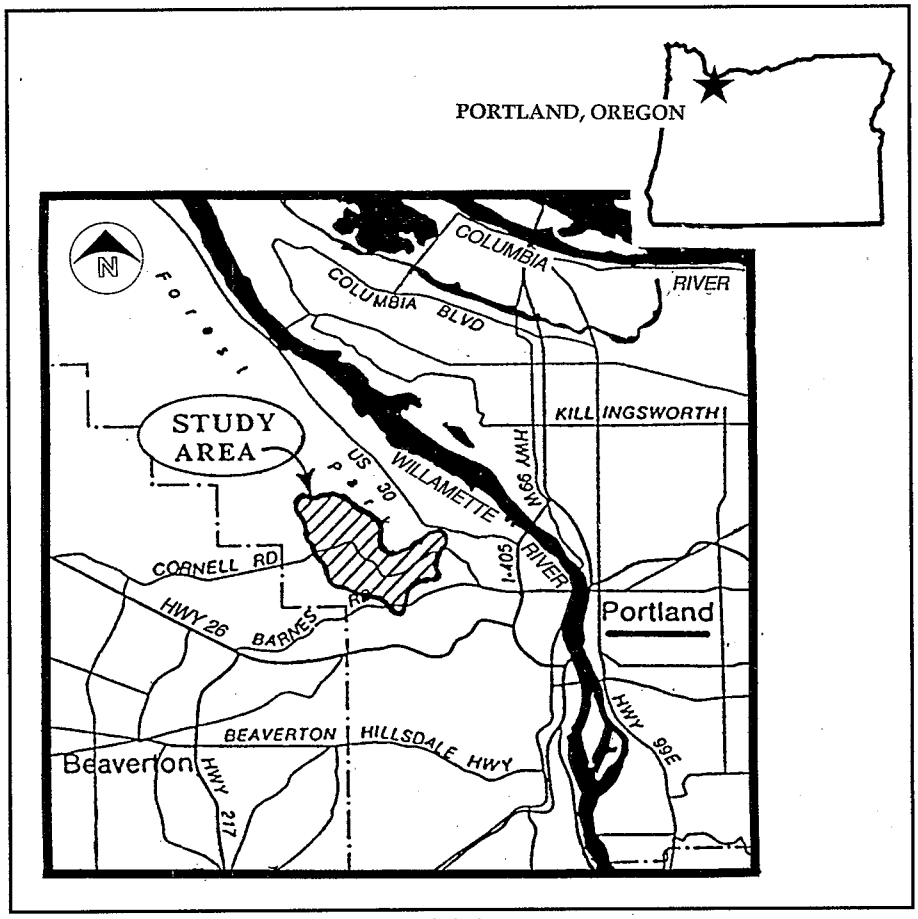

Figure 1. Balch Creek watershed vicinity map.

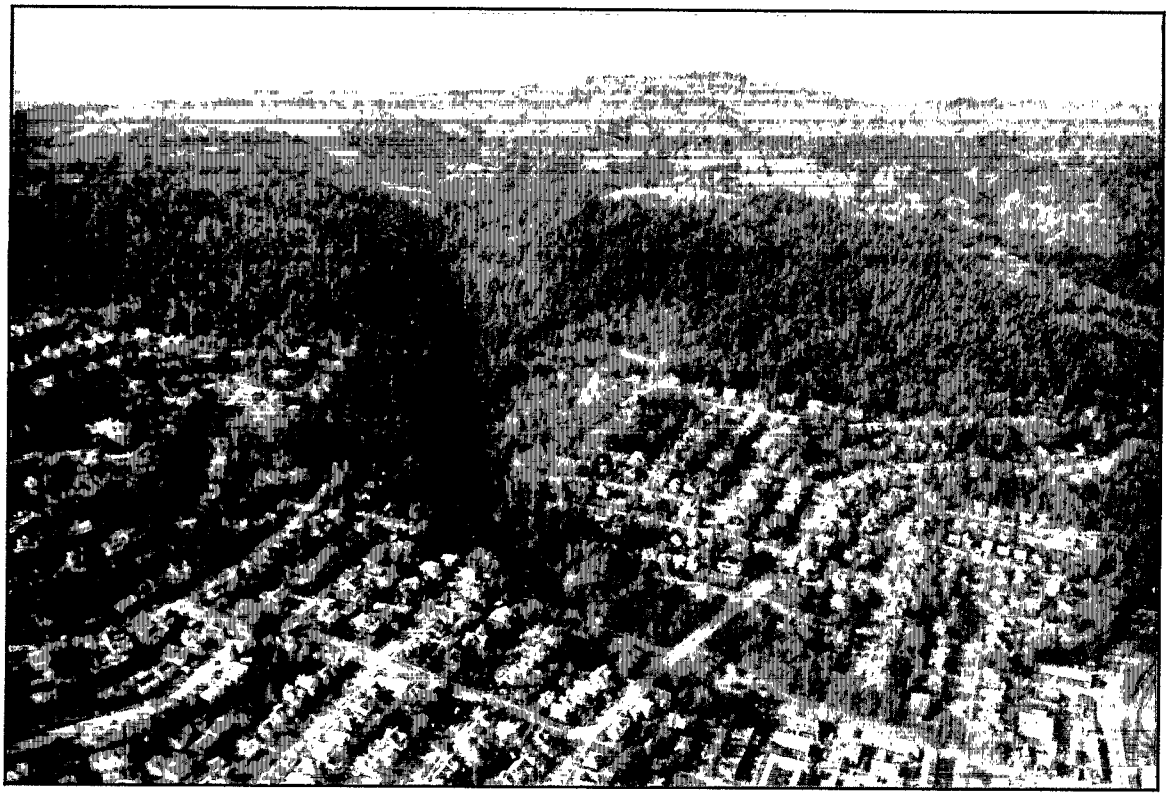

Photo 1. View to the southwest of the Balch Creek Watershed and canyon, with residential and lower industrial area in the foreground.

As part of the planning effort, the Balch Creek Citizens Task Force (BCCTF) worked with BES to prepare a *Concept Plan* that will guide the planning, and this plan is one of the project's more unique features. It was developed early in the process and consists of short policy statements which are recommendations to BES. The benefits of the process are that interested citizens formally expressed their views at the beginning of the planning which allowed the project team to locate the political "hot-spots" early. It also provided a low-pressure opportunity for the project team to provide educational information to the task force.

An important watershed resource for the plan to protect and enhance is a population of cutthroat trout in Balch Creek which has been isolated for over 70 years due to the downstream pipe. One of the most important objectives of the plan is to reduce the threat of damaging floods such as those which occurred in 1955 and 1970 in the lower industrial area. The plan will also address water quality, since runoff from the entire watershed flows into the Willamette River through an outfall which the Oregon Department of Environmental Quality will permit under National Pollutant Discharge Elimination System (NPDES) constraints. Wildlife, although less tied to the Creek and its resources than the fishery, is also an important aspect of the project. The SMP will address erosion-sedimentation by augmenting the Balch Creek Watershed Management Plan previously adopted by the Portland City Council. The most controversial issue has been recreation-education use at the pilot project due to site neighbors being concerned about the additional visitors in the area.

The following discussion has been taken from the *Balch Creek Watershed Storm water Management Plan Background Report* (City of Portland, 1993).

Geology and Soils

The Columbia River Basalt, overlain by the Troutdale Formation and the Sandy River Mudstone, are the primary geologic units in the basin. The Troutdale consists of sandstone, siltstone, and claystone; and the Sandy River Mudstone consists of siltstone and claystone. The Columbia River Basalt consists of dense, fractured rock.

Much of the Balch Creek Watershed is covered by an erodible soil know as "Portland Hills Silt," which often has a "fragipan" soil layer about two feet below. Fragipan soils allow little water to flow through, so the ratio of surface runoff and shallow groundwater flow to infiltration and deep ground-water movement tends to be high in the portions of the watershed where these soils occur. The high runoff rates and steep slopes create high flow velocities which are more likely to cause erosion of the silt-fragipan soils and others in the watershed. The Soil Conservation Service classifies the silts as the Goble and Cascade Series. The Wauld Series predominates in Macleay Park near Balch Creek and comprises eroded-deposited soils from the watershed.

Vegetation

Much of the Balch Creek Watershed has been logged and is covered by deciduous tree species such as red alder, big leaf maple, Scouler's willow, and bitter cherry. Conifers are also abundant and include Douglas fir, grand fir, western red cedar, western hemlock, and western yew.

Erosion-Sedimentation

When protective cover, usually vegetation or small amounts of forest litter, is removed and the mineral soil is disturbed and exposed, erosion in the Balch Creek Watershed increases dramatically. Erosion may occur in small increments over a large area through "surface" erosion processes, or in concentrated flow rivulets which turn into gullies. It may also occur in large volumes through deep underground soil movements; some barely noticeable at the surface. Such "mass" erosion can be caused by the destruction of plants and root structure, high soil moisture, cuts into the slope which remove soil support, or a combination of these factors.

Erosion is important in the watershed because the eroded soil, which is eventually deposited as sediment at downstream locations, smothers fish spawning areas and fills the scarce pools needed by the Balch Creek cutthroat trout. The sediment also impairs the aesthetics of the creek, recreational values at Macleay Park, and Balch Creek water quality. In addition, when sediment fills stream channels and culverts the potential for damage due to flooding is increased.

In February of 1992, a mass movement of soil occurred in the watershed due to improper soil storage and the effects can be seen all the way through the downstream reaches of Balch Creek and Macleay Park (Photo 2).

Hydrology and Flooding History

The large proportion of the watershed which is covered by vegetation should favor lower surface runoff rates and volumes, but this is offset somewhat by the steep slopes. The shallow, relatively impervious fragipan soil layer impedes the deep percolation of precipitation into the soil and forces it to reemerge relatively quickly in small channels and rivulets. The net effect is surface runoff volumes during actual flood events that are relatively high for the size of watershed and type of soils involved. The flood peaks are slightly less than the volume would indicate due to travel time delays caused by the shallow ground-water flow, or "interflow," which reemerges as streamflow slightly after the peak of the surface runoff component. The hydrograph peak also occurs a little later than expected, and possibly extends over a longer period of time. The comparison of the HEC-1 hydrograph with real hydrograph data confirms that this is occurring.

The Balch Creek flood peaks and volumes based on the hydrologic modeling in Lower Macleay Park at the storm sewer entrance are as listed in Table 1. At the low-flow end of the hydrologic regime, the flow at Lower Macleay Park during September 1992 (a drought year) was usually less than 0.5 cfs, and this extended over a number of months.

The Balch Creek Basin has experienced serious flooding problems twice

Table 1. Balch Creek flood peaks and volumes

Recurrence Interval	Peak Flow cubic feet per second (cfs)		Volume acre-feet (ac-ft)	
	Existing	Buildout	Existing	Buildout
2-year	125	170	137	158
5-year	220	272	193	232
10-year	273	327	230	272
25-year	366	423	298	345
50-year	448	507	356	406
100-year	529	593	417	470

Photo 2. Deposits from the mudslide that occurred in a southern tributary in the upper portion of the Balch Creek Watershed.

since 1921 when the industrial area was filled and lower Balch Creek was contained in the storm drain pipe. In 1955, during high flows a stump lodged in the pipe, which pressurized and ruptured, and flooding of property occurred. In 1970, the pipe again pressurized due to surcharging at the Macleay Park inlet, ruptured, and caused significant amounts of property damage to industries, a highway, and a railroad. The upper one-fourth of the storm sewer has been replaced with 84-inch diameter reinforced concrete pipe but the rest is 66-inch diameter and provides the hydraulic capacity constraint (410 cfs) to the system (Barrett et al., 1975).

Fish

The primary fish species in Balch Creek is the native cutthroat trout. The viable population of 2000 to 4000 fish has apparently been isolated since 1921 due to the construction of the storm sewer. According to the Oregon Department of Fish and Wildlife (ODFW) this isolation may have created an important genetic resource (Blaylock memo to Ochsner, 1992). Fishing is not allowed but the trout contribute to valuable education and passive recreation uses. Due to fish migration for spring spawning, the ODFW has stated that fish passage structures are needed at all detention/water quality facilities. The most important fish enhancement needs are additional pools, riparian habitat for cover, and the removal of passage blocks.

Water Quality

Balch Creek water quality is generally good with elevated levels of nutrients and suspended solids. The nutrient concentrations are sometimes above the regulatory limits usually established in Oregon. The suspended solids alter stream structure and degrade fish habitat when they settle in the pools. The most likely source of phosphorus and suspended solids is eroded soil, and the most likely nitrogen source is septic tank effluent. Fertilizers may also contribute nutrients to the system. Since future water quality problems may be implied but are not currently a regulatory or technical issue, preventative action based on the SMP is timely.

Wildlife

The Balch Creek watershed is part of the West Hills area which supports 11 species of amphibians, 10 species of reptiles, 112 species of birds, and 62 mammal species (City of Portland, 1990). Since the watershed is adjacent to a populous urban area, the wildlife is one of its most valuable resources.

Recreation-Education

A considerable portion of the watershed is managed as parks (292 acres), sanctuaries (109 acres), or open space (67 acres) according to the Portland Bureau of Planning (1990). This is approximately one-third of the watershed and illustrates the importance of passive recreation and outdoor education in the area. The park and sanctuary lands are managed by the Portland Bureau of Parks and Recreation and the Portland Audubon Society, and are utilized by the Portland School District and citizens throughout the region.

Land Use/Institutional

The Balch Creek Watershed includes land both within the Portland city limits and within unincorporated Multnomah County. The City of Portland's land use and environmental protection regulations are generally viewed as adequate for managing new development on lands within the city limits. In unincorporated Multnomah County, development of the lands outside the Urban Growth Boundary is regulated by the State Forest Practices Act. These regulations may not provide adequate protection for all development activities and resource values.

The Storm Water Management Plan

The evaluation of alternatives for managing storm water and related resources for the Balch Creek Watershed is currently being completed. The techniques which are likely to be recommended are discussed in the following sections.

Citizen Participation

The Balch Creek Watershed has a history of citizen involvement in governmental matters that affect the area. One of the Nation's largest urban parks, Portland's Forest Park, runs into the watershed from the north. The Portland Audubon Society owns or manages a significant amount of land in the watershed and operates its office, educational activities, and wildlife care center from a building complex within the watershed. In addition, many schools and special education programs use the watershed since it is relatively natural and close.

Because of the active citizen interest in the watershed the BCCTF was formed to provide plan formulation advice. It was decided to ask for such advice early in the planning process through the BCCTF development of a *Concept Plan* which recommended planning policy in six categories—flood control, water quality, fish, wildlife, recreation-education, and land use/institutional. That plan contains 58 recommended policies—some that are basic and noncontroversial and some that have major implications and are controversial. A few paraphrased recommendations are as follows:

- Provide funding assistance to homeowners who may need to improve on-site wastewater facilities to resolve water quality problems, but who cannot afford them.
- Develop on-site and regional water quality and quantity facilities such as wetlands.
- Implement cooperative, intergovernmental programs that are consistent with each other, particularly involving land use and fish.
- Assign a high budgeting priority to monitoring watershed conditions and facility performance.
- Regional flood detention facilities should be evaluated in conjunction with water quality wetlands throughout the watershed.
- Protect and enhance the cutthroat trout population.
- Provide additional pool habitat for the trout (this appears to be the limiting factor).
- BES and ODFW should jointly prepare a fish management plan for Balch Creek, which fits ODFW criteria for such plans.
- Provide fish passage at all water quality wetlands.
- Provide limited public education-recreation access at water quality and flood control facilities, including the Pilot Project.

- Consider public-private cooperative programs, including funding, for the watershed, particularly involving educational activities.

Erosion-Sedimentation

Erosion and the related sedimentation constitute one of the most serious watershed problems. The slopes are steep and the soils are erodible. The generally sparse development, the amount of land in public ownership, and the strict land development requirements have offset these factors somewhat.

The plan will address erosion-sedimentation on both a preventative and mitigation basis. The preventative measures could involve watershed controls that support and augment the Balch Creek Watershed Protection Plan prepared by the Portland Bureau of Planning in December 1990. The basic approaches to controlling erosion-sedimentation involve:

- Minimizing the total area, duration, and season of soil exposure (much of this is being done now).
- Requiring new developments to be designed to minimize storm water runoff velocities, surface flow rates, and erosion through minimum road widths and impervious areas, vegetated swales, detention storage, and infiltration systems.
- Enforcing tight controls on soil excavation, fill, and storage.
- Providing mitigation facilities such as sedimentation ponds and wetlands in or below existing developments and problem areas.

Water Quality

The Balch Creek water quality is generally good, but elevated levels of phosphorus, nitrogen, and suspended solids have been observed. Future problems can be avoided through preventative actions. The most likely sources in need of control include soil disturbance and exposure due to land development/clearing, chemical applications of fertilizers or herbicides, septic tank effluent, and impervious area runoff.

Water quality improvement can be accomplished through a number of approaches including:

- Additional erosion-sedimentation controls.
- Additional watershed and water quality monitoring to identify problem areas and suggest mitigation measures.
- Reducing the impact of nutrient sources such as septic tank effluent.
- Pond-wetland facilities designed for water quality improvement.
- Vegetated swales and other biofiltration facilities.
- Infiltration of runoff in carefully selected soils that will accept additional water.

Flood Control

Flood problems have occurred in the past (1955 and 1970) and the hydrologic modeling performed for this project indicates that peak reduction is needed. The goal is to reduce the future 50- and 100-year recurrence interval storm runoff to the 410 cfs capacity of the downstream pipe which runs through the industrial area.

The approaches being considered to reduce the potential for flood damage include:

- Detention-storage facilities, usually including pond-marsh water quality functions.
- A maintenance plan that integrates a number of objectives and methods.
- More emphasis on conveyance techniques that reduce runoff velocities.
- Infiltration of runoff from developments where geotechnically feasible.
- Increasing the size of the downstream pipe. (This option was estimated to cost over $3 million in 1982, not considering hazardous materials disposal which would likely be involved due to the soil excavation.)

Fish Habitat Enhancement

The cutthroat trout in Balch Creek have been determined to be a viable population requiring protection and enhancement. A more intensive fish evaluation using a quantitative analysis method entitled the Instream Flow Incremental Methodology (IFIM) (Bovee, 1982) is now being performed on Balch Creek and includes an intensive evaluation of the Pilot Project site.

Previous fish assessments have indicated that unlike many northwest

streams, the limiting factor in Balch Creek is pool habitat rather than riffle-gravel habitat. Cutthroat trout move upstream to spawn in the spring and a number of barriers to fish passage exist, primarily involving culverts. Riparian vegetation is absent along much of the main reach of Balch Creek, primarily due to heavy recreational use from a trail which parallels the Creek. During low-water periods fish harassment occurs from domestic animals and recreationalists.

The fish habitat enhancement techniques being considered include:

- Increasing the amount of pool habitat available in the creek and new pond-wetland/detention facilities.
- Providing fish passage components in the pond-wetland/detention facilities.
- Removing or mitigating existing fish passage barriers.
- Improving riparian habitat and cover to enhance shading for temperature control, reduce predator/nuisance access, and increase food supply.
- Improving in-stream structure for cover/protection.
- Possibly increasing the spawning area available.

Wildlife

The most promising wildlife management techniques involve creating wetland habitat in association with storm water detention and water quality projects. Access and observation areas could be included at various levels in the design of such projects to provide for education and passive recreational uses. The educational use would emphasize integrated natural resource values such as the fish and wildlife habitat and water quality improvement characteristics of wetlands. Interpretive information would be made available and possibly other means of watershed/environmental education sponsored.

Research and Concept Development

Although it was not initially envisioned as a research and development project, it is now obvious that the SMP and the Pilot Project will establish a number of technical and regulatory precedents, and provide an excellent opportunity for long-term performance monitoring. The primary areas of interest are:

- Designing flood detention in conjunction with water quality wetlands.
- Designing fish enhancement features for water quality wetlands.
- Constructed, on-stream water quality wetland design.
- Creating fish passage at existing culvert barriers and into/through on-stream wetlands.
- Obtaining water rights for constructed wetlands (which has turned out to be a significant time constraint).
- Evaluating water quality wetland treatment performance.
- Developing analytical methods for estimating performance of combined flood detention and water quality facilities.

The Pilot Project

The Pilot Project involves the construction of a flood detention facility to reduce peak flows; one or two wetland units in the lower part of the detention facility to improve water quality; and the inclusion of fish pools in the wetlands (Figure 2). The project also includes native riparian and shading vegetation, a fish passage structure from the existing culvert to the wetland pool, recreation-education access and observation areas, and an initial sedimentation unit.

The project utilizes an existing road fill to create flood storage volume and the wetland units. Optional features include spawning gravel enhancement upstream and raising the road fill by 5 or 6 feet to create additional storage capacity.

Flood Control

Approximately 2 miles below the Pilot Project, Balch Creek enters an 84-inch diameter reinforced concrete pipe, which transitions after approximately 1,000 feet into a flatter 66-inch diameter monolithic concrete pipe. The smaller pipe has less capacity and provides the hydraulic constraint of 410 cfs to the system (Barrett et al., 1975). The total length of pipe is approximately 6,000 feet.

The 50-year and 100- year recurrence interval storms produce peak runoff of 450

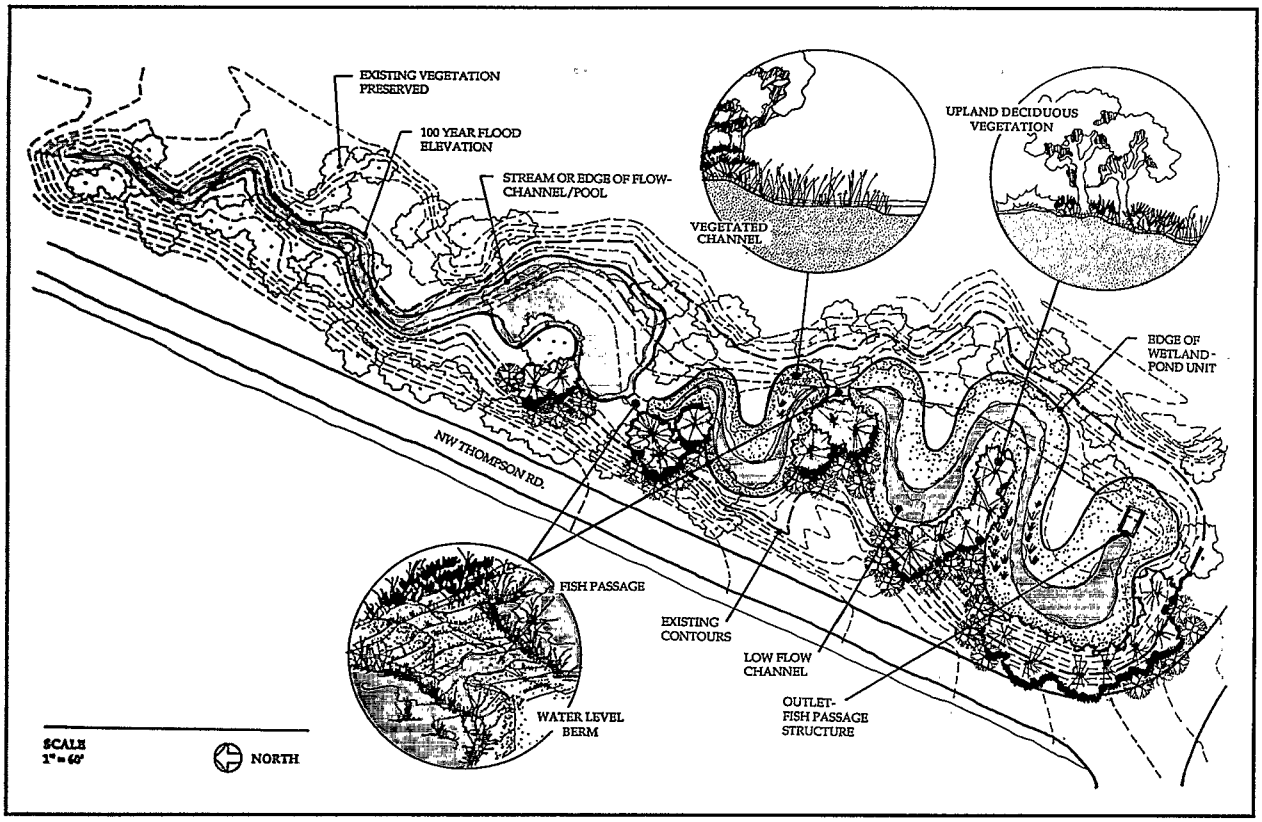

Figure 2. Conceptual plan of the early action "Pilot Project" site.

and 530 cfs, respectively, for current conditions, and 510 and 600 cfs for future conditions. The Pilot Project can provide over 30 percent of the 120-cfs peak reduction needed to match the 100-year, current conditions runoff peak with the pipe capacity. It can provide over 20 percent of the future conditions, 100-year peak reduction. If 5 or 6 feet is added to the road fill, the percentage of peak reduction benefits needed become 55 and 35 percent, respectively.

It is important to note that it was never anticipated that the Pilot Project could achieve all of the peak reduction needed by itself. The intent is to implement enough detention-storage projects in the watershed to reduce the flooding risk in the industrial area and avoid the need to replace approximately 5000 feet of pipe at a probable cost of over $4 million.

The storage space will be created by two existing road fills and the natural topography. An orifice plate will be placed on the existing culvert under Cornell Road to limit the peak flow passing through the culvert. The storage capacity behind the road fills will be used like a "surge tank" to reduce the peaks during a range of events, with emphasis on the 100-year recurrence interval storm. A spillway will be included to divert water back into the existing pipe if blockage of the orifice-outlet occurs.

Water Quality

The State of Oregon is currently establishing total maximum daily loads (TMDLs) for many streams, and this may eventually include Balch Creek. The most likely possibility that TMDLs would apply to the Creek is that they would be established for the Willamette River, to which Balch Creek is a tributary, and load allocations would be implemented for tributaries, such as Balch Creek. The other water quality performance objective for BES is to implement most effective practices (MEP) for the watershed to comply with NPDES storm water requirements, which will apply soon.

Since specific water quality targets have not been established for Balch Creek, the informal water quality target for the pilot project is assumed to be 0.100 milligrams per liter (mg/l) to 0.200 mg/l total phosphorus, which is close to the 0.070 mg/l TMDL

established for the Tualatin River, a slow stream with algal growth problems southwest of Balch Creek. Water quality samples from Balch Creek show total phosphorus levels in excess of the 0.100 to 0.200 mg/l target.

The water quality portion of the project is conceptualized as consisting of an initial sedimentation unit to reduce impacts on the lower wetland unit(s) and to concentrate maintenance activities. The total surface area of the wetland and initial unit is anticipated to be approximately one acre.

The objective of the wetland unit is to provide approximately 30 percent reduction of total phosphorus, 20 percent reduction of nitrate-nitrogen, and 50 percent reduction of suspended solids during the runoff from storms which are exceeded twice per year (the "6-month" storm). Since there are no regulatory targets at this time, the water quality objective is an informal guideline. The intent is to design the facility for maximum effectiveness, monitor its performance, and use the information to refine the design approaches for such facilities in the future. Maximum removal is expected to occur at a flow less than the design storm runoff.

Fish Habitat Enhancement

The Oregon regulatory agencies, including the federal agencies, are attempting to approve permits for projects involving wetlands expeditiously but in a manner which is consistent. For projects like the Pilot Project, which is small and will create and restore wetland and stream habitat, this presents timing problems. Every permit and review check-off required of large, environmentally-damaging projects is necessary for the pilot project. One of the most difficult review check-offs is from the ODFW for fish protection.

Balch Creek's remnant cutthroat trout population requires additional pool habitat, adequate spawning gravel, fish passage in the spring, adequate water quality, temperature, cover, and food. The Pilot Project is being designed to provide more pool habitat, instream and riparian cover, and food. It will also mitigate spawning gravel if necessary, provide fish passage during a mid-range of spring flows, and provide riparian vegetation which protects against temperature increases.

The sinusoidal nature of the Pilot Project wetland is designed primarily to prevent short circuiting and lengthen the flow path for water quality. By deepening the channel at certain locations, low-flow pools will be created for fish refuge during drought years. The fish ladder will be near the outlet and fits with northwest fish passage criteria. The native riparian habitat will consist of brush along the bank which can overhang the water, fast-growing medium-height trees, and taller trees for long-term shading. Depending on the IFIM fish survey results, spawning gravel mitigation will be provided if needed. One of the most important aspects will be the performance monitoring after project construction since the integration of fish provisions in small projects such as this is not well understood.

Wildlife, Education, and Recreation

The Balch Creek Watershed is rich in wildlife and much of it is well protected despite its proximity to an urban area. However it does not contain very much wetland habitat, and the project will increase that type of habitat and the wildlife diversity. Currently the site is primarily vegetated by Himalayan blackberries, which are not native and have low to moderate wildlife value.

The educational/recreational values will be provided primarily through modest public access, interpretive signs, and one or two viewing areas. Although this aspect of the project is not a major design consideration, and the BCCTF Concept Plan states that such use should be provided, it appears to be the only major, controversial issue. Three neighboring property owners have objected to any public access, apparently because of a fear of increased crime.

Special Issues

A number of special issues add interest, and difficulty, to the project.

Interagency Cooperation

Although the Pilot Project and SMP provide increased levels of environmental benefits, the permits intended to protect the environment are difficult to obtain at this time. This primarily involves the time required for communication, information collection and presentation, and application processing. It is made more difficult by the

lack of credible precedents from a regulatory perspective, and the Balch Creek work should help future similar projects in this regard.

Concept Development

Some of the Pilot Project features and SMP methods are somewhat new in Oregon. The work performed is intended to provide performance information on a number of planning and design concepts, which could be applied to other watersheds.

Early Action Projects

The Pilot Project was intended to demonstrate BES' commitment to implementing storm water solutions involving flood control, water quality, and fish management. It is also strengthening the SMP by forcing the BES-Montgomery team to address issues and details often overlooked in planning.

Concept Planning

The BCCTF Concept Plan has resulted in two types of process benefits. It allowed early public participation in the planning at a vital policy level. It also supports sound but sometimes controversial planning objectives while warning the project team of futile pursuits, thereby saving money.

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The West Maui Algal Blooms and Watershed Management

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The Problem

Beginning in 1989, blooms of macroalgae (seaweed) began to appear in great quantities off the west coast of Maui, Hawaii (Figure 1). These blooms consisted of the green alga *Cladophora sericea* and an introduced red alga *Hypnea musciformis*. The *Cladophora* drifted on the sea floor, tangling in coral heads, damaging coral, and driving fish and divers away from the reefs. The more buoyant *Hypnea* formed floating mats that came to rest on the beaches where it was a nuisance to beach goers and residents. Residents living next to storm water channels that had filled with rotting algae lodged numerous health complaints.

The problem of the West Maui algal bloom was brought to the U.S. Environmental Protection Agency's (EPA) attention in the fall of 1991 as a result of four congressional inquiries. Also that fall, the Hawaii Department of Health (HDOH) created the West Maui Algal Bloom Task Force. The Task Force is composed of members of the West Maui community and local government agencies. The purpose of this Task Force is to collect information on the Maui algae and recommend necessary studies and possible abatement actions. In the spring of 1992, EPA formed its own Maui Algae Team consisting of staff from various EPA programs. EPA and HDOH, together, have developed a preliminary watershed management strategy, outlining needs for applied research and suggesting nutrient source controls.

West Maui Geography

The West Maui Watershed is a 16-mile stretch of mountains, plains, and coastline where sugar cane and pineapple fields may be found alongside golf courses, resort hotels, and one of the most popular diving meccas in the United States. In this watershed, land use falls in distinct bands that parallel the coast (Figure 1). In the upper reaches of the watershed, rainforest covers the mountains. At the base of the mountains, sugar cane and pineapple are cultivated on steeply sloping plains. Along the coast, urban development is rapidly replacing agriculture.

Over two dozen streams deeply incise the coastal mountains. To the south the streams are perennial, whereas to the north they are annual because of greater precipitation. West Maui is the dry side of the island, receiving at the coast approximately 8 inches of rainfall per year. In the watershed's mountains, however, rainfall exceeds 400 inches annually. This, coupled with the steep topography, can cause brief but torrential flooding. In an attempt to control flooding, agencies are installing storm water channels and sediment retention ponds in the major streams.

Underneath the watershed is a freshwater aquifer that floats on top of a saltwater aquifer (Figure 2). The freshwater aquifer is recharged by mountain rains and irrigation that induce a net seaward flow of fresh water. In some locations, the freshwater aquifer extends seaward of the shoreline and causes fresh water to seep from the shallow sea floor. Like surface water, pollutants discharged to the ground water in this

watershed eventually reach the ocean unless they are transformed or removed in the aquifer.

Tropical waters are naturally nutrient-poor, which means that any increase in nutrients, especially nitrogen and phosphorus, could produce an algal bloom if other conditions are favorable. In the West Maui area, there are many potential nutrient sources that may affect ground water and surface waters flowing into the ocean. These sources include treated sewage effluent disposed into coastal injection wells; fertilizers that are used on sugar cane and pineapple crops, golf courses, and resort landscaping; sewage from cesspools, septic systems, and leaking sewer lines; and nutrients released back into the water from algae decomposing on the shore. To assess the magnitude of these sources EPA is currently conducting a preliminary nutrient assessment, the results of which will be used to direct further research and nutrient source controls.

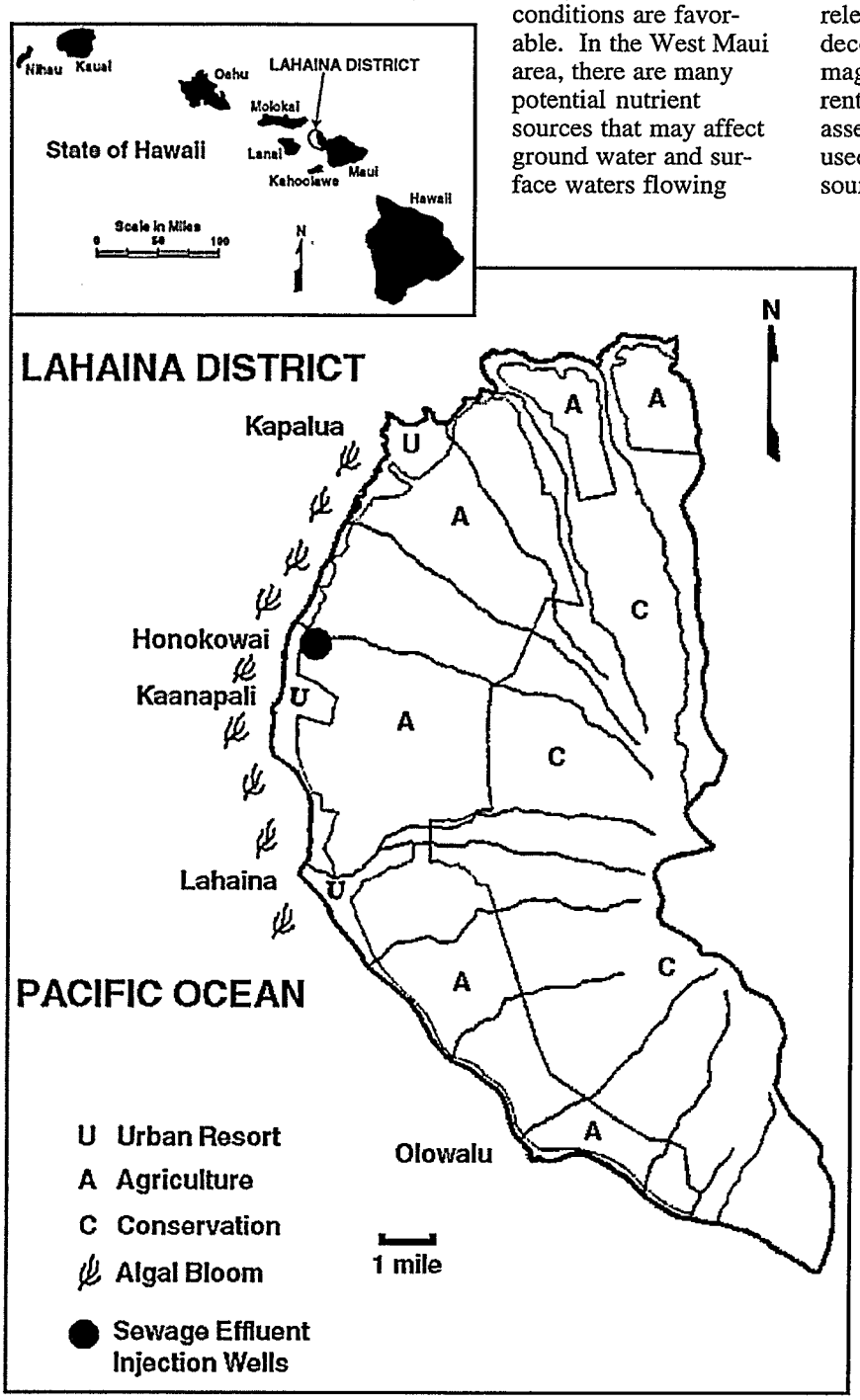

Figure 1. Land use zoning in the Lahaina District of Maui and the reported extent of the algal blooms.

EPA/HDOH Watershed Strategy

To help investigate the causes of and possible solutions to the algal blooms, Congress appropriated $400,000 and $450,000, respectively, to EPA and the National Oceanic and Atmospheric Administration (NOAA). In cooperation with HDOH, EPA and NOAA are presently determining what further studies and actions will be needed. Maui County, sugar cane and pineapple agribusinesses, the U.S. Soil Conservation Service (SCS), and the University of Hawaii are also being consulted.

EPA and HDOH have developed a joint watershed strategy to understand and combat the algae bloom. This strategy outlines several applied research projects to determine how and why the algae grows so prolifically, and lists several immediate steps that can be taken to reduce the flow of nutrients into the near coastal waters.

To date, funded applied research projects include a tracer study to determine if effluent from the sewage injection wells is reaching the ocean; an algae mapping effort; an assessment of the biodiversity of the coral reefs to determine if algae-eating predators are missing; and a study of algae physiology. Additional projects under consideration include employment of a watershed coordinator on Maui to review the various research projects and work with the Maui community; the monitoring of surface water, ground water, and

submarine ground water seeps; and a cost assessment and feasibility study of nutrient removal from the injected sewage effluent.

EPA is also pursuing, in conjunction with HDOH, Maui County, SCS, and agribusiness, a number of nutrient source control activities, including reclamation of the treated sewage effluent and demonstration projects in which best management practices (BMPs) would be used on agricultural land. Another course of action that might help mitigate the algae problem is removal of algae from beaches and removal of sediment from sediment retention basins and storm water drainage channels.

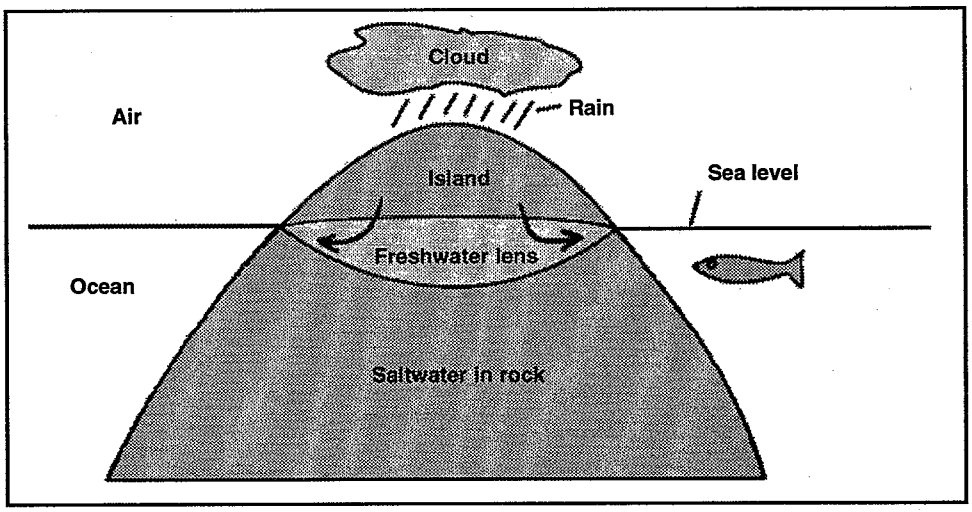

Figure 2. Vertical cross-section of an island depicting the Ghyben-Herzberg lens that is a lens of fresh water floating on saline water.

Summary

The West Maui Watershed is home to a unique combination of land use, from large-scale agriculture to resorts, set in a terrain that extends from mountainous rain forest to a semi-arid coastline. Though it may take years of study to determine the precise cause of the algae bloom, an attempt must be made to abate the bloom by reducing nutrient loading from all potential sources. EPA and HDOH have devised a watershed strategy blending applied research and nutrient source controls. The success of this strategy hinges on active participation of all those who have a stake in protecting the coastal waters of West Maui. This includes Maui County, SCS, NOAA, local citizens' groups, and agribusinesses.

Conserving a River Ecosystem: A Missouri River Partnership

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During the past 50 years, over 95 percent of the Missouri River's original wetland habitat, 90 percent of its sandbar habitat, 75 percent of its stream aquatic habitat, and 66 percent of its wooded riparian habitat have been lost, largely through human activities. This has resulted in the elimination or reduction of native species. At present 50 plant or animal species are listed under the Endangered Species Act or are under one of the review categories for listing consideration.

Increased competition for the resources of the Missouri will likely perpetuate a growing list of litigation challenges. And, those processes set in motion will further reduce natural heritage values of the river. The U.S. Fish and Wildlife Service (Service) believes that an approach exists to help resolve use conflicts along the river through active protection of the river system. The Service, in its responsibility for encouraging the protection of the Nation's fish and wildlife resources, proposes the establishment of a Missouri River Partnership to facilitate the planning and coordination needed to protect and enhance the river's diversity and health.

The Service, through informational inquiry, determined the level of concern about Missouri River resource issues. The following questions were posed to interested federal, state, tribal, and local governments, and to nongovernmental groups in the Missouri River Basin:

- Do you see long-range resource problems on the Missouri River?
- Do you see the development of a broad restoration plan for the River as a needed activity and the offer of the Service to act in a facilitator role in plan development as a proper role for the Service to play?
- What programs or activities are you now doing, or do you plan to do, that could be utilized in a river restoration partnership program?

The response to the first question was an overwhelming *YES*. Numerous issues and resource problems, as well as recommendations, were identified. These include the following:

- Continuing and prolonged disagreement within the Basin over resource uses is accompanied by continuing litigation which appears to have no visible end.
- There is a lack of meaningful dialogue based on sound biological information and processes to improve communication and, thereby, avoid conflicts.
- Competing use for limited resources is growing and plans and investments to expand future use of the resources are faced with slowly diminishing and deteriorating natural resources.
- There is a growing concern over contaminants and the sources of resource contamination.
- A process to interface cooperative efforts between the many management and regulatory entities having impact on the welfare of the resource is sorely needed.
- There is a need for an agency, like the Service, to begin facilitation of communications and cooperative efforts between the wide range of Missouri River resource users.

- There are growing concerns over the allocation of limited resources.

The Service was encouraged by the positive nature of these responses, and is proposing the following goal:

> *Facilitating; in cooperation with interested governmental, tribal and private parties; the recovery of the natural resource values and environmental health of the Missouri River Ecosystem, for the benefit of Basin residents, consistent with existing resource uses.*

The Service proposes that the *Missouri River Partnership* involve all interested entities in the Basin. We need to emphasize that the program is *not* designed to change current uses, compete with other programs, or impede ongoing efforts. We believe that mechanisms can be found to restore many of the River's natural functions in a manner that is compatible with existing river uses. The task ahead is formidable, but the potential benefits to *all* Basin residents makes the effort worthwhile.

Program Objectives

- Facilitate establishment and coordination of an operational Missouri River environmental resource management, restoration, and enhancement program involving federal, state, tribal and local governments, and public interest groups.
- Coordinate the preparation, facilitation, and implementation of a comprehensive action plan for the management, restoration and enhancement of fish, wildlife and related environmental and recreational resources within the Missouri River ecosystem in concert with existing uses.
- Develop and implement plans for providing fish and wildlife resource-based recreational opportunities for the people of the Missouri River ecosystem.
- Establish a functional outreach program to involve and exchange information with the public concerning problems, opportunities, and resource management and restoration needs in the Missouri River ecosystem.

Proposed Program Legislation (Missouri River Fish and Wildlife Cooperative Restoration Act)

Review suggests that additional legislation would assist in directing such a complex coordinating activity. Within 2 years of enactment, the Director of the U.S. Fish and Wildlife Service would be required to conduct an evaluation and submit a report to congress concerning the status and the management, protection, and restoration needs of fish and wildlife in the Missouri River Basin.

- The evaluation would be conducted in cooperation with the states, tribes, other federal agencies, and with private groups within the Basin.
- The report would include specific recommendations for projects that could be implemented to halt the decline and restore populations of fish and wildlife that are or may be subject to provisions of the Endangered Species Act.
- The report would also include broader recommendations on other actions that might be taken to protect and restore the natural biodiversity of the Missouri River ecosystem. Such actions might include the development of additional information, as well as joint projects or management activities that might be undertaken in a coordinated manner by the study partners.

Program Initiation Process

- The Service would facilitate establishment of a Steering Committee with representatives of all interested local, state and federal agencies, tribes, private organizations and individuals from throughout the Missouri River Basin.
- Service and other agency employees would serve as staff to the Steering Committee.
- The Steering Committee would identify resource management problems, information needs and a format for a basin-wide Missouri River Plan of Action. Working groups then would be established to

develop information and alternatives for problem solutions. Steering Committee staff would chair each working group.
- Products of the working groups then would be incorporated by the Steering Committee staff into a Missouri River Plan of Action, with emphasis on utilization of existing authorities, capabilities and programs to better manage the Basin's natural resources.

Program Implementation Process

- The Missouri River Plan of Action would identify existing authorities, capabilities, programs, and activities of participating partners which could be utilized to address resource management problems.
- The Plan of Action would include a Cooperative Agreement for signature by participating partners, indicating that each will abide by the provisions of the Plan and utilize identified authorities, programs and activities to accomplish the goal of the Plan.
- The Cooperative Agreement would commit the participating partners to obtaining funding commensurate with the responsibilities identified in the Plan of Action.
- The Plan of Action also would identify appropriate new authorities and funding sources which may be needed to achieve the goal of the Plan.
- The Plan of Action would include provisions for long-term documentation of the environmental and economic benefits derived from implementation of the Plan.

Program Products

- A system-wide approach to determine the status, trends and effects of activities on the Missouri River.
- Summary information for managers to guide efforts for impact prevention, remediation, restoration, and enhancement of fish and wildlife resources.
- The Plan of Action and Cooperative Agreement.

Other Related Activities that Could Complement the Missouri River Partnership

- *Missouri River Master Manual Review.* Water management is the primary activity that impacts all river-related resource management in any river basin. The Partnership Program would utilize products from the Master Manual Review process to update plans, make recommendations, and identify possible projects.
- *Missouri River Mitigation Project.* The Missouri River Mitigation Project is a program with a finite limit of funds and projects. The Partnership Program could be coordinated with the Mitigation Project to ensure that both programs are complementary by incorporating information from the mitigation projects into other projects or activities. The Partnership Program would want to review the successes of the Mitigation Project and monitor the contributions the projects make in restoring health to the system as a whole.
- *Missouri River National Fish and Wildlife Refuge Studies.* This ongoing Service activity will be conducted in full coordination with the Partnership Program. Various Service programs could be used to contribute to the partnership packages.
- *Mississippi Interstate Cooperative Resource Agreement (MICRA).* MICRA is a state-sponsored group which focuses on the fishery resources of the entire Mississippi River Basin, of which the Missouri River is a part. The Partnership Program is narrower in geographic scale, but broader in terms of the resources being targeted.
- *Missouri River Natural Resources Committee (MRNRC).* The MRNRC is a state-sponsored group involved with coordination of river resource activities of interest to the seven state fish and wildlife conservation agencies on or along the Missouri River. It is anticipated that the MRNRC will be an important coordination point for partnership planning and priority setting.

- *Wing Beats Over the Prairie.* The Great Plains tribal natural resource departments, with assistance from the U.S. Fish and Wildlife Service and the Bureau of Indian Affairs, have developed a wetland and watershed enhancement initiative. Wingbeats Over the Prairie is an interagency and intertribal initiative to enhance wetlands and associated habitats for migratory birds, threatened and endangered species, and fisheries.
- *Great Plains Initiative.* The Great Plains Initiative is an attempt at an ecosystem-wide approach at managing wildlife and habitat instead of focusing on individual species. It offers an opportunity for the Great Plains states to take early action to prevent the listing of troubled wildlife species under the Endangered Species Act. The premise of the Missouri River Partnership Program is similar but focuses on the river ecosystem.

The System—As It Was

Until this century, the Missouri River was characterized by ever-eroding banks, shifting side channels, heavily wooded islands, and myriad sandbars. The River's constantly changing nature supported one of North America's most diverse and extensive riparian ecosystems. Its meandering nature, abundant side channels and oxbows, wooded islands, backwater areas, floodplain wetlands, sandbar complexes, extensive floodplain forests, and wet prairies supported an abundant and diverse assemblage of aquatic and terrestrial organisms. This *oasis* provided sustenance and served as a mode of conveyance for distribution of lifeforms across the grassy plains of the mid-continent.

The *Big Muddy* once flowed through sparsely populated areas settled by Native American peoples and served as a natural travelway between the Eastern woodlands and the Rocky Mountains. In 1803, the United States purchased much of the Missouri River basin through the *Louisiana Purchase*, and a new era of human development and settlement began. In the relatively short span of 150 years, the Missouri River and its basin were dramatically transformed to serve a growing country. As settlement expanded, human needs and desires focused on the unpredictable River and its rich alluvial floodplain.

The federal government initiated numerous activities in 1912 intended to tame the Missouri River ecosystem. A process of closing side channels and constricting the River between dikes and wooden pilings was begun to create a navigation channel 6 feet deep from the mouth to Kansas City, MO. In 1933, the federal government began construction of the first large dam on the mainstem of the Missouri River in support of navigation. This structure, Fort Peck Dam, was later included in multipurpose plans adopted in 1944, commonly termed the *Pick-Sloan Plan.*

In 1941, the federal government began constructing a system of levees along the lower Missouri River to protect thousands of acres from the threat of periodic flooding. A more comprehensive plan to alter the lower river was authorized in 1945 as the *Missouri River Bank Stabilization and Navigation Project.* This project deepened the channel to a minimum of 9 feet, and extended construction works to Sioux City, IA. This project and the Pick-Sloan Plan forever altered the River's anatomy. The succeeding 28 years found the unpredictable Missouri River a *tamed* system, controlled by over $10 billion worth of dams, reservoirs, and channelization works.

The System—Changes

Physical Changes

Today, the Missouri River is vastly different from that of even 50 years ago. Originating in the Rocky Mountains of south-central Montana, it flows 2,300 miles, traversing seven states and passing through seven mainstem dams, built and maintained by the federal government. Over 900 miles, or nearly 60 percent of the former upper River, now lie under permanent multipurpose reservoir pools. The lower 733 miles consist largely of a highly constricted navigation channel regulated by flows released from the upstream reservoirs. Channelization works have shortened this lower River section by 127 miles.

Although less than 1 percent of the River remains in a natural state, three reaches—the National Recreational River

reach (Gavins Point to Ponca, Nebraska), the Scenic River reach (headwaters of Lewis and Clark Lake to Fort Randall Dam), and the Wild and Scenic River Section (Morony Dam near Great Falls to Robinson Bridge near the headwaters of Fort Peck in Montana)—are recognized as retaining especially unique natural values. Other sections retaining largely natural morphologic characteristics are the 140-mile reach between Fort Peck Dam and the headwaters of Lake Sakakawea in North Dakota, and an 80-mile section between Garrison Dam and the headwaters of Lake Oahe also in North Dakota (Figure 1).

Existing as a complex natural system for thousands of years, federal development programs have caused profound physical and chemical changes to the River over the past 20 to 50 years. Construction of the mainstem dams transformed the *Big Muddy's* upper reaches from a heavily silt-laden, braided stream into a series of deep, cold-water reservoirs.

Natural riparian vegetation that existed historically along the River's banks provided a constant source of organic material to the natural system. However, these nutrient and energy inputs were lost with inundation; now the main source of these basic fuels is local runoff. Net phytoplankton production in the upper mainstem reservoirs, the main source of present-day primary production feeding the system, is comparable to that of nutrient-poor, oligotrophic lakes. Little submergent or emergent aquatic vegetation can exist because of the adverse effects of severe wind action and extensive water level fluctuations, attendant with the semi-arid climate of much of the Basin and regulation for flood control and navigation purposes.

The downstream channelized River is characterized as a single rock-lined channel, with swift currents and very limited habitat diversity, that is largely unsuitable for recreation or many components of biological communities. Flow is regulated largely

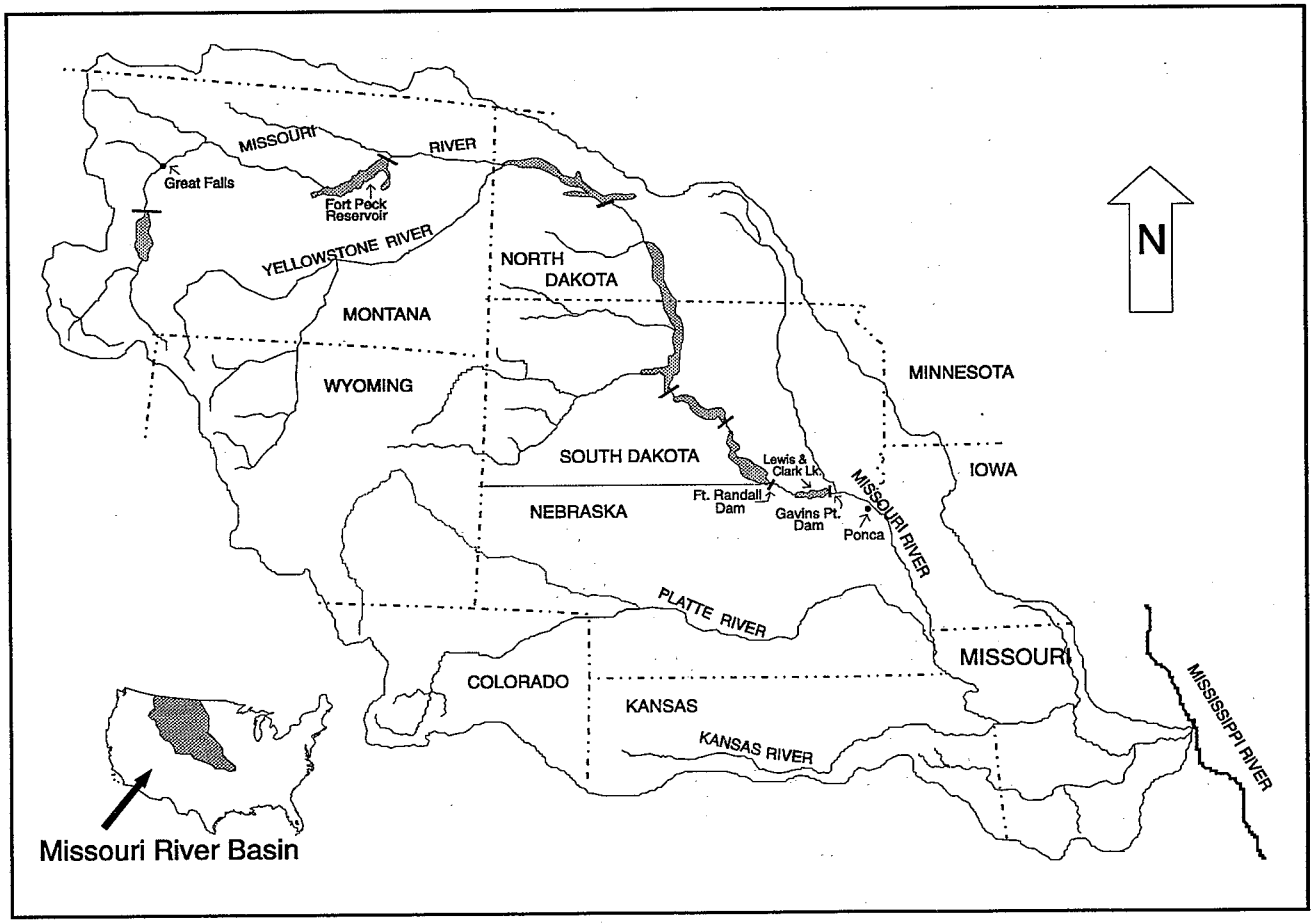

Figure 1. Map of the Missouri River Basin.

by releases from the mainstem reservoirs, attuned mainly to navigation and flood control needs, rather than to management of a viable biological system. Since each reservoir traps the silt arising from tributary streams, the water released is clean, but relatively unproductive.

This rapidly-moving, sediment-starved water gnaws at its confining channel downstream of the dams, resulting in shoreline erosion, riverbed degradation, and decreased water surface elevations at any given discharge. The lowered riverbed, in turn, results in depressed ground water levels, degradation of tributary streams, and drainage of adjacent backwater chutes, oxbows, sloughs and other floodplain wetlands, further diminishing habitat and reducing the abundance and diversity of indigenous fish and wildlife species. Channelization has exacerbated the bed degradation process in many River reaches. Present priorities for managing water in the system include the needs of fish and wildlife resources, but only so long as flood control and other purposes are not compromised.

These human-induced alterations have eliminated hundreds of thousands of acres of highly productive riverine and floodplain wetlands that were hydrologically dependent upon the River. Over a million acres of riparian woodlands and wet prairies have been converted to more intensive land-uses. The natural River ecosystem, throughout its length, was dependent upon these habitats as an important source of primary and secondary production, as well as nutrient cycling. Approximately 95 percent of the original floodplain (1.8 million acres), in the reach downstream of Sioux City, IA, has been converted to intensive agricultural, industrial, and municipal uses.

Another unforeseen impact of human-induced changes is the continuing, insidious bed aggradation occurring along the extreme lower reaches. This phenomenon is caused by periodic sediment deposition between the levees during flood stages, and is especially visible near the mouth where the River enters the impounded Mississippi. Each succeeding flood event increases the Riverbed elevation between controlling levees. The future bed of the lower Missouri may well rise to levels above the protected lands within its old floodplain.

Fish and wildlife resources, especially, have experienced detrimental impacts as a result of physical alterations to the system, as well as from competition for the use of its water. The many competing uses of and demands on this River, the Nation's longest and one of its most-altered, creates a situation ripe for human conflict.

Biological Changes

As the Missouri River changed, so did the aquatic and terrestrial wildlife community that depends so completely upon it. Impoundment, channelization, and subsequent control of water discharges have eliminated some species and significantly reduced population levels and reproductive success of others. Currently, 8 fish species, 15 birds, 6 mammals, 4 reptiles, 6 insects, 4 mollusks, and 7 plants indigenous to the system are either listed by the federal government as threatened or endangered or are under status review for possible listing. Others are likely to follow, if the trend of habitat alteration and depletion continues.

One of the Missouri River species groups most severely impacted by changes in available habitats is the endemic fish populations. These species evolved with a nearly unlimited availability of embayments, brushy habitats, and flooded vegetation for use as spawning, rearing and feeding areas. The artificial reservoirs, which offer deep, cold, open water habitats, provide unique conditions but are seldom used by many indigenous aquatic organisms. Endemic large river species, like the sturgeons and paddlefish, moved long distances, required free-flowing streams for spawning, and were attuned to natural fluctuations in discharges and stages that triggered their reproductive cycles. The artificial, highly fluctuating flow regimes, together with seven confining mainstem dams and reservoirs, also altered water temperature regimes. Inundation of portions of 122 tributary streams has had serious consequences for many of the large river species as well.

The diverse ecological community that was once the Missouri River also has been seriously altered by those processes set in motion by levee construction, subsequent land-use changes, channelization, and resulting channel aggradation and degradation. Although the River ecosystem likely will never be returned to its predevelopment state, some of the ongoing destructive processes can be checked and the overall condition of the ecosystem improved. Actions can be taken toward recovery of Missouri River biological integrity and its

recreational potential, while retaining developmental purposes, such as flood control and water supply.

The Challenge

A holistic plan of action will be required to accomplish the needed rejuvenation of the Missouri River. This plan must involve all federal, tribal, state, local and private entities interested in the River's well-being. A coordinated, system-based approach is proposed, which includes recognition of the needs of the Basin's fish and wildlife resources, and the public benefits they impart, in addition to traditional developmental needs and values.

No effort to manage the Missouri River as an ecosystem has yet been attempted, so this is a precedent-setting endeavor. In this initiatory venture, careful planning for the future path of Missouri River management is paramount. To be successful, however, full recognition must be given to the significant contribution played by the system's biological resources, and the importance of ecological processes, not only to our own welfare, but to that of future generations.

To this end, we propose to be guided by the following goals and objectives. From these we will develop specific tasks and projects to be initiated cooperatively by each partner in this joint action program.

Goal and Objectives

Program Goal

To facilitate, in cooperation with interested governmental, tribal, and private parties, the recovery of the natural resource values and environmental health of the Missouri River ecosystem, for the benefit of Basin residents, consistent with existing resource uses. We believe that improvements in the biological productivity and recreational value of the system can be made which are complementary to existing and future navigation, flood control, and water supply needs.

Objectives

I. To facilitate establishment and coordination of an operational Missouri River environmental resource management, restoration and enhancement program involving federal, state, tribal, and local governments, and public interest groups.
   1. Establish research, monitoring, modeling and predictive capabilities for Missouri River ecosystem resource management, including development of a common data base which can be accessed by all resource users, managers and planners.
   2. Secure a funding base, consistent with the importance of the Missouri River ecosystem relative to other budget priorities.
   3. Develop and coordinate a process for obtaining consensus among the management agencies, tribes, and the public in prioritizing and implementing management, enhancement and restoration efforts, consistent with existing resource uses.

II. To coordinate the preparation, facilitation and implementation of a comprehensive action plan for the management, restoration and enhancement of fish, wildlife and related environmental and recreational resources within the Missouri River ecosystem in concert with existing uses.
   1. Facilitate organization and coordination of a planning team made up of representatives from management agencies, tribes, resource users, and the public.
   2. Identify and organize special expertise work groups with responsibility for completion of specific research, management, restoration and enhancement projects critical to the recovery of the Missouri River ecosystem; these projects will be designed and implemented in cooperation with existing resource uses.
   3. Focus facilitation efforts on development and implementation of joint projects to recover populations of species listed as threatened or endangered with extinction, and species suffering declines which may lead to such listing; this will include restoration of sloughs, backwaters and other riverine and floodplain wetlands, riparian woodlands, wet prairies, sandbars, and other key habitats supporting natural diversity of the System.
   4. Identify long-term, system-wide fish and wildlife resource management

opportunities to meet conservation, restoration and enhancement objectives.

5. Identify contaminant-related concerns and conduct research needed to resolve contaminant-related issues and ensure quality habitat restoration.

III. To develop and implement plans for providing fish and wildlife resource-based recreational opportunities for the people of the Missouri River ecosystem.

1. Establish and maintain a program to coordinate and collect pertinent recreational use information, including demand levels, and user values and interests, as well as opportunities for recreational development in the Missouri River ecosystem.
2. Evaluate sociological trends and patterns pertinent to fish and wildlife resource-based recreation in the Missouri River ecosystem and develop a coordinated program to meet public demand.
3. Jointly develop and facilitate implementation of programs to enhance fish and wildlife resource-based recreational potential of the Missouri River system, consistent with habitat management, restoration and enhancement objectives, and complementary to existing resource uses and needs.

IV. To establish a functional outreach program to involve and exchange information with the public concerning problems, opportunities and resource management and restoration needs in the Missouri River ecosystem.

1. Establish a mechanism to involve the public, communities, and private industry in addressing natural resource management issues in the Missouri River ecosystem.
2. Create and provide opportunities for local and private groups to share in the restoration of the Missouri River ecosystem, and facilitate implementation of projects that complement developmental needs.
3. Establish a forum for the many system users to participate in the identification of resource problems and formulation and implementation of solutions that will avoid or resolve resource use conflicts.

Approach

Based on congressional mandates, the Service is to provide leadership in the conservation of the Nation's fish and wildlife resources for the benefit of the people. Although the Service possesses the professional experience and expertise needed for the proposed Missouri River effort, other agencies share in these mandates, both from the standpoint of legal authority and land management expertise and responsibility. Also, a number of programs presently are underway, or are in various stages of planning, which may contribute to improvement of the *Missouri River ecosystem.*

The Service's program goal and objectives do not compete with these ongoing efforts. Rather, the proposed *Partnership* activities would serve to facilitate definition and implementation of long-range resource management, restoration and enhancement programs, from a system-wide standpoint, and document progress toward the accomplishment of conservation purposes. The Service proposes to utilize the expertise of other agencies and groups to assure that solutions formulated meet conservation goals and are compatible with developmental needs. The Missouri River Partnership will be a basin-wide effort, including coordination among the States of Montana, Wyoming, Colorado, North Dakota, South Dakota, Nebraska, Kansas, Minnesota, Iowa, and Missouri; other federal agencies; Indian tribes; local governments; private organizations; and the general public. Coincident with preservation and enhancement of fish and wildlife resources, public recreational potential also will be assessed and improved where consistent with resource management objectives.

Information for this effort will be obtained through:

1. Synthesis of existing data and identification of information needs.
2. Field data collection to fill data gaps.
3. Analysis of synthesized and newly acquired data to address resource management issues.

Literature reviews and results of consultations with resource experts from both government and the private sector will serve to determine the need for field investigations and other data collection efforts. Information assembled will be used to formulate alternative management plans in concert

with the objectives of this proposal. An important work product will be a habitat-based method for evaluating progress achieved toward recovery of the Missouri River ecosystem per unit of fiscal and staff input.

The proposed program will address all 2,300 miles of the historic floodplain of the Missouri River and will fulfill a coordination and facilitative role for current environmental programs that are serving, or could serve, resource management, restoration and enhancement objectives.

Implementation

Considerable effort is needed to perform the proposed evaluations, to identify the restoration opportunities available, to coordinate and facilitate proposed and ongoing restoration activities with other interested parties, and to ensure compatibility with existing resource uses. Additional fiscal resources will be necessary to ensure successful completion of this effort in a timely manner, and to enable appropriate participation and involvement of other agencies and organizations having resource management responsibilities. The complexity of this task suggests the need for congressional support and direction. Informal discussions, both within and outside the Service, have led to a preliminary view of what a potential legislative concept might involve.

Development of a Restoration Action Plan

The program would focus on development of a restoration plan for the Missouri River ecosystem. The Director of the U.S. Fish and Wildlife Service would be authorized to:

- Conduct a comprehensive evaluation of the status of fish and wildlife resources along the River in light of past, present and future River uses as they affect the physical, hydrological, and ecological characteristics of the River. The evaluation would involve the states, tribes, and appropriate federal and private agencies and groups concerned with, and interested in, management and protection of fish and wildlife resources and their habitats.
- Identify and evaluate all options currently available from agency and private programs that could serve to protect, manage, or restore fish and wildlife resources and their habitats.
- Develop recommendations and plans, in cooperation with the other resource interests, to encourage and utilize the best of these options for restoration activities.
- Develop an outreach program to involve the public in plan development. This likely would require incorporation of local plans into the overall restoration goal to ensure that the effort would not replace or usurp any ongoing programs which are or could be restorative in nature; the program would encourage joint development of concepts designed to mesh effective restoration actions.

Involvement of Other Entities Having Resource Management Responsibilities or Interests

It is expected that the resource status evaluation and development of restoration action plans would take 2 to 3 years, if adequately funded. The Service would propose to conduct the effort with existing personnel, drawing upon special expertise from within the agency. Memoranda of understanding, cooperative agreements, Interagency Personnel Act assignments, and other suitable processes would be utilized to bring other special expertise into the effort and help ensure meaningful involvement of other participants. When utilized, these agreements would formally outline participant roles and responsibilities.

Some interests may opt to detail staff to the effort at their own expense, while others may choose to participate only in a review capacity. It is anticipated that formal joint venture plans and agreements likely would result for many localized restoration efforts, and cooperative agreements would also be developed for accomplishing longer range goals.

Outline of Evaluation Approach

Evaluation of historical developments as they may have affected present conditions would be important in relation to predicting future trends and potential impediments to restoration opportunities. Identification of potential restoration activities that are currently available or ongoing, as well as

potential future activities, would be an important first step to a coordinated approach to ecosystem restoration.

Present and future implications of contaminant and nonindigenous species threats to long-term restoration and management goals and options also would be addressed. Recommendations as to monitoring needs to ensure that restoration is being accomplished, and that it is being executed in an efficient and prudent manner, would likely be included.

In addition, recommendations regarding future planning or technical assistance needs of participants, the possible development of a continuing forum for interjurisdictional entities to continue dialogue regarding management of resources, and potential cost or cost-sharing arrangements for future restoration activities on the River, would be anticipated. The legislative directive likely would include reporting requirements and a final report containing recommendations for future efforts and management activities.

Summary

The Missouri River is a tremendous natural resource that has served to sustain a diverse biological community, including humans, for thousands of years. During comparatively recent times, modern humans have harnessed the River's resources for various developmental purposes, including flood control, navigation, irrigation, and municipal and industrial water supply. The vast majority of the River's floodplain has been converted to crop production, inundated by reservoirs, or dedicated to other developmental purposes; in addition, many tributary streams have also been altered.

This extensive habitat alteration has caused fish and wildlife and other natural resource components of the Missouri River ecosystem to suffer. Many are at the point of being extirpated, or listed as threatened or endangered with extinction. Conflict among resource users has culminated in litigation among states and agencies.

The U.S. Fish and Wildlife Service proposes that this *Missouri River Partnership* involve all interested entities in the Basin. Together, we believe that mechanisms can be found to restore many of the natural functions which created and sustained this river that are compatible with existing and future developmental uses. The task ahead is formidable, but the potential benefits to *all* basin residents and resource users makes the effort well worthwhile.

Mitchell Creek Watershed: Nonpoint Source Pollution Implementation Program

Maureen Kennedy Templeton, Grand Traverse County Drain Commissioner
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Background

Michigan is blessed with an abundance of fresh water that most people in the world can only dream about. Northwest Michigan's position on the eastern shore of Lake Michigan exposes it to a constant supply of lake effect rain and snow riding the prevailing westerly winds and dropping on the forests and fields of the countryside. From the moment those raindrops strike the earth they continue to seek out the path of least resistance and move downhill under the invisible force of gravity. But each raindrop could end up taking any number of routes to a variety of destinations. The watershed comprises the complete system of surface water and ground water, taking in the entire drainage basin for a main watercourse. Watersheds obey only gravity and the movement of water. They ignore the boundaries of man. The Mitchell Creek watershed includes all the land areas that drain into Mitchell Creek, and in turn is a subwatershed to the Grand Traverse Bay. The Grand Traverse Bay adjoins Lake Michigan, which covers a portion of the Great Lakes watershed. The Great Lakes watershed joins forces with other rivers from eastern North America and finishes its trip to the Atlantic Ocean through the St. Lawrence River watershed.

Watersheds define communities. As Mitchell Creek connects us to places as far flung as the ocean, so it connects us in a special way with our neighbors. Caring for the watershed is a community responsibility—the result of one's actions impact everyone downstream. And it befalls every individual to use the precious watershed responsibly and protect the lifeblood of the community.

What we call the Mitchell Creek watershed is a 14.7-square-mile (9420-acre) portion of Grand Traverse County that spans parts of Garfield and East Bay Townships and the City of Traverse City. On the south and west, the watershed is bordered by the Boardman River watershed and on the east by the Acme Creek watershed. The creek system includes seven main tributaries with over 20 miles of perennially flowing stream channel and many more miles of intermittent streams that become active in the spring thaw and rainstorms. Mitchell Creek is the third largest watershed that empties into the Grand Traverse Bay.

The creek is defined as a "gaining stream," which means that ground water makes a significant contribution to the streamflow. Considering the fact that the creek drains a region of very porous soils and erodible land, Mitchell Creek's reliance on ground-water flow makes it extremely vulnerable to damage from human activity. Although the creek contributes only 2.75 percent of the total tributary flow into the Grand Traverse Bay, that flow amounts to about 5 dump truck loads of water per minute.

Forests now cover 31 percent of the watershed surface. Orchards and croplands account for 26 percent and fallow fields make up about 20 percent. Urbanized lands now comprise about 13 percent.

In 1969, the Michigan Department of Natural Resources (MDNR) classified the

main stream of the creek as "top quality trout stream." To gain that classification, the creek met standards of cold water temperature and high levels of dissolved oxygen, and the stream still contains trout species such as brown and brook trout today. Although the water quality of the creek has remained within acceptable range, tests show a quality level below that of the average Michigan trout stream and a steady increase in pollutants.

In 1991, the Grand Traverse County Drain Commissioner and the MDNR commissioned Battelle Great Lakes Environmental Center and Gosling Czubak & Associates to perform an indepth study on nonpoint source pollution in the Mitchell Creek watershed. The results substantiated what many had already suspected, that increased human activity in the watershed were accelerating levels of nonpoint source pollutants. Nitrogen and phosphorous compounds were found in greater concentration than found during sampling in the 1970s.

Toxic chemicals also pose a threat to the Mitchell Creek watershed. Currently, eight sites of Act 307 contamination (the Michigan Environmental Response Act of 1982) have been identified in the watershed, five of which are located in porous soils and four of which are adjacent to the creek. None of these sites have been completely cleaned up. Two of the sites have contaminated about 140 drinking wells, and the contamination "plume" in the ground water has now reached the East Arm of the Bay, raising benzene levels to four times the U.S. Environmental Protection Agency "suggested chronic toxicity level." The groundwater contamination caused the local government to install a city water system for the effected households.

Our knowledge of watershed dynamics has grown considerably. The tools and techniques for contamination cleanup and prevention are now accessible to everyone in the community. The supporting momentum for environmental safeguards has gone from being a handful of isolated voices to the status quo.

The Mitchell Creek watershed implementation project comes in the nick of time.

According to the last census, Grand Traverse County grew at one of the fastest rates in the State of Michigan. More people live in the County than in 1980, and most of those have settled in areas like the Mitchell Creek watershed. Over the same period, total residentially zoned acreage in the watershed has also increased by 47 percent, a trend that will continue with the attraction of the recently opened East Bay Middle School. Extensions of sewer and water lines allow for denser and accelerated development, which will be encouraged by the widening of Hammond Road and the possible construction of the Traverse City bypass. Five industrial parks and a large portion of the regional airport fall within the boundaries of the watershed. The people who work in the offices and factories of these parks (and their families) will all need places to live.

Ironically, the very features that attract new residents, clean air and water, safe streets, uncrowded recreational lands, and available well-paid jobs, are the very features that are most threatened by a surge in population growth. Public officials see the imminent growth and have developed comprehensive plans for East Bay and Garfield Townships. All of the local jurisdictions in the watershed are zoned communities, but zoning regulations alone will not guarantee the quality of life around Mitchell Creek. The future of our environment boils down to the activities of each and every member of the watershed—in our homes, work places, playgrounds, and all points in between.

Clearly, if we are to preserve Mitchell Creek in a condition approaching what it is today, watershed residents will have to break with the conventional pattern and search out new ways to live in harmony with natural dynamics. The Mitchell Creek watershed implementation project attempts to make this a reality.

Anticipated Accomplishments

Throughout the implementation project there are a number of items that we would like to accomplish. Following is a description of each.

Land Protection Program

Grand Traverse County has contracted with the recently organized Grand Traverse Regional Land Conservancy to coordinate and implement a land protection and public education program within the watershed. The Grand Traverse Regional Land Conservancy's mission is to protect signifi-

cant natural, agricultural, and scenic areas and promote land stewardship now and for future generations.

Through this unique partnership the Regional Conservancy will be working with landowners in the Mitchell Creek Watershed to permanently protect critical lands within the watershed through the Conservancy's voluntary land protection programs. A committee of watershed landowners guides the Conservancy's efforts to assist landowners willing to permanently protect the wetlands, streamside greenbelts, and ground-water upland recharge areas on their property. Every landowner within the critical areas of the watershed will be contacted by the Conservancy to discuss the various land-protection programs offered by the Conservancy. The goal of this portion of the project would be to have all of the watershed critical areas protected in some manner. Presently the Conservancy has been successful in retaining a 60-acre parcel of the critical wetlands area that will be made into a nature reserve.

The education opportunities are very exciting. The Conservancy has put together an outstanding *Mitchell Creek Watershed Landowner's Handbook.* This publication will be mailed to every property owner within the Mitchell Creek Watershed. Items covered within the manual include The Creek, Watershed Care, Land Protection, Regulations, Implementation, and a Mitchell Creek Watershed Map. There will also be a series of workshops to give property owners the chance to learn best management techniques "hands-on."

Watershed Planning

Presently each jurisdiction has its own individual master plan for development. None of the plans takes into account the uniqueness of the watershed that crosses political boundaries. Through this task we would like to explore the idea of looking at this area as a watershed and produce an efficient integration of land uses in regards to the resources and community character we would like to preserve.

Geographic information system (GIS) information that will be generated as part of this project will be expanded upon and manipulated to assist in this planning effort. The goal of this task is to develop a recommended development plan for the communities. As a second step we will divide the watershed into sectors and actually produce some conceptual development plans for these areas. The idea of an urban services boundary will also be explored.

Resource Monitoring

A resource monitoring program will be set up in the Mitchell Creek Watershed. Through the original nonpoint source planning study, baseline information on the water quality of the stream was gathered. This effort will be expanded upon during the implementation phase to continue long-term monitoring. In addition to the water quality chemical parameters being looked at, a biological assessment program will also be put in place. This, along with the chemical analysis should give us firm ground to study any significant impacts to the watershed from ongoing development.

Flow monitoring will also be a very important part of this program. We plan to develop monitoring stations on two separate tributaries of the stream. One stream will be a tributary that is experiencing rapid urbanization. The other tributary will will be in an area that has much less development occurring. This will give us the opportunity to study the impact of best management practices that are being used within the watershed. As an example, the county has a Stormwater Management Ordinance that requires each development to retain any additional storm water generated from the site on their site. There is no available community stormsewer system to which areas can discharge. We need to determine if the requirements we have for development are adequate and if they are found to not be adequate make changes in our storm water management policy. This two-tributary approach should help us determine this. A hydrological analysis of the watershed that was done by MDNR during the planning study will act as baseline for this step.

Presently the Northwest Michigan Council of Governments is working with the students within the watershed to do stream monitoring. The stream is in the vicinity of two elementary schools and the recently opened East Junior High School. The opportunity for involvement and education of the students is tremendous. This stream monitoring is part of the Global Rivers Environmental Education Network (GREEN) system. The students are connected by computer with other

students throughout the state, country, and world.

Best Management Practices

Four different agencies are assisting with this task. Michigan State University (MSU) Extension, Grand Traverse Regional Land Conservancy, Soil and Water Conservation District, and the Grand Traverse County Road Commission are all taking action within the watershed.

MSU Extension is working with all of the recreational facility owners within the watershed. These people include the Traverse City School System, Mitchell Creek Golf Course, and Elmbrook Golf Course. Present turf management practices will be studied and recommendations given to each facility on potential improvements that could be made for the benefit of the resource as well as economics. Any areas of the stream that go through these facilities will be reviewed for the need of additional vegetative buffer areas. If this is found to be a problem, some funds are available to assist the property owners in establishing these buffer areas. Extension will also attempt to develop an appropriate fertilizer mix for use within the watershed for recreational facilities as well as residential and commercial sites.

Years ago, when the East Bay Elementary School was developed in the watershed, a section of the school was designed to traverse the stream. The area of the stream that the school crosses presently has no buffer area. The lawn from the schoolyard goes right down to the stream. The Grand Traverse Regional Conservancy has been successful in receiving funds from Michcon, a local gas company, to establish a buffer in this area. They will be developing a plan and then working with the students to actually put this in place. The Soil and Water Conservation District is assisting the Conservancy in developing the buffer plan.

The Conservation District will also be assisting agricultural property owners within the watershed. The purpose of their work is to suggest a cost-effective means of implementing agricultural best management practices in the Mitchell Creek Watershed which will result in the reduction of agricultural nonpoint source pollution. Technicians will work with owners within the watershed to develop pesticide, herbicide, and animal waste spreading plans where appropriate. Any areas of the stream that cross agricultural property will be looked at in regards to the adequacy of the buffer area on each site. If more buffer is necessary for the protection of the stream, we will offer assistance to the property owners in establishing these areas.

The Grand Traverse County Road Commission is planning a number of major road improvements within the Mitchell Creek Watershed. For the first time their philosophy will be to mitigate the impacts of the roads with storm water management controls. The community supports the efforts of the Road Commission on this item. Monitoring will be done in locations where the roads cross the stream both prior to construction and after to determine if these controls are making a difference.

Mapping

A GIS will be established for the watershed area. All existing map layers will be put into the County system, all parcels will be digitized, and a database on the parcel will be started, which will aide us in the watershed planning that we need to accomplish.

Through Northwest Michigan Council of Governments (NWMCOG) and Great Lakes Environmental Center (GLEC) a wetlands map will be generated for the watershed to aide area planners with decision making. The Michigan Resource Information System (MIRIS), the Soil Conservation Service Soils Map, and U.S. Fish and Wildlife Service wetland maps will be compared and overlayed on a GIS to determine more accurately where the existing wetlands are located within the watershed. GLEC will overlay onto this existing mapping a satellite image of the watershed for comparison of where wetlands show up. Then we will have field verification done to determine which overlays or combination of overlays are the most accurate. We are hoping that this exercise will aid us in determining if the use of satellite imagery would be cost-effective for determining the location of wetlands throughout the Grand Traverse Bay Watershed.

Watershed Management Authority

Drainage law in the State of Michigan allows for the election of a Drain Commissioner within each county whose responsibilities are storm water management for

both rural and urban development. Through this law, areas can be managed on a watershed basis if the communities petition the Drain Commissioner to do so. If this is the case, a Drainage District is set up to pay for any improvements that are needed within the given watershed. This concept will be explored as part of this project to determine if there is a need to establish the district at this given point in time. Items such as long-term stream water quality monitoring and flow monitoring could be taken care of within this type of Drainage District.

The Mitchell Creek Watershed Implementation Program is being looked at as a model to use for other watersheds that drain into Grand Traverse Bay. Pollution prevention is the key to maintaining the area's integrity. Hopefully one day we will have this same type of integrated effort in each and every watershed within the Bay Region.

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Protecting Estuarine Resources: An Integrated Framework for Land Use Decision Making

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The San Francisco Bay/Sacramento-San Joaquin Delta estuary (Bay/Delta estuary) comprises the San Francisco, San Pablo, and Suisun bays and the Delta of the Sacramento-San Joaquin rivers, two large rivers that drain the Central Valley of California; it is the largest estuary on the west coast of the Americas. The region continues to be one of the most popular and rapidly developing areas in the United States. The population for the 12-county Bay/Delta region is projected to increase by over one million people during the next two decades. Pressure for expansion is being applied particularly to areas outlying existing urban centers. Population growth and corresponding changes in land uses could have detrimental effects on the estuarine ecology, unless resource protection efforts are better integrated with land use management. The most notable impacts could be increased discharge of pollutants, the continued alteration of critical habitats such as wetlands and stream environments, and increased diversions of freshwater flows.

The region historically supported an estimated 545,375 acres of tidal marshes. San Francisco Bay accounted for approximately 200,375 acres and the Delta accounted for approximately 345,000 acres (Meiorin, 1991). These extensive wetlands provided extraordinary fish and wildlife habitats, major spawning grounds for finfish and shellfish, and key stopover sites for migratory birds. Not surprisingly, these resources also attracted human settlement. Around the Bay, some marshes were converted to agricultural uses, while a significant portion were converted to salt production basins. In the Delta, wetlands rich with layers of peat soils were diked and drained to make productive farmland.

Today tidal marsh acreage of the Bay/Delta estuary is estimated at 44,371 acres (Meiorin, 1991). This represents the conversion or loss of 92 percent of the estuary's historic tidal marsh habitat. These converted wetlands retain vital biological characteristics and provide opportunities for enhancement, but their wetland functions and values have been substantially degraded. Beginning in the 1960s, growing environmental awareness has led to decreased rates of wetland degradation and conversion, but the trend continues nonetheless.

Current Land Use Regulation

In California, local government has the primary authority to regulate land use, and therefore possesses the capacity to minimize impacts associated with land use change. Local government is charged with making decisions about zoning, building permits, infrastructure, housing, and related services. California law provides the authority for local land use decisions and establishes the framework for those deci-

*The views and recommendations expressed in this paper are those of the authors and do not necessarily reflect the policies of EPA or the San Francisco Estuary Project (SFEP).

sions. Each city and county must prepare a comprehensive General Plan containing state-specified elements oriented toward meeting local goals and needs. All local ordinances, development plans, and activities are required to be consistent with that plan; but local governments are not required to coordinate their plans with adjacent communities or resource agencies. Moreover, no effective regional entities have been established to coordinate development, and local plans need not meet regional or state goals for wetland protection. Finally, there is not an appropriate forum for the review of local plans, nor are there standards for judging the adequacy of these plans.

According to a recent survey, a majority of local governments in the 12-county area have adopted General Plan policies for protecting wetland or stream environments. However, less than 15 percent of these entities have adopted specific ordinances or other regulations to implement these policies. Each of the 111 local governments in the Bay/Delta estuary area can, and often do, have differing goals, policies, and regulations concerning use and treatment of estuarine resources. Though current land use planning laws provide a framework that can be used to protect natural resources, there are not land use requirements in place to ensure the protection of the region's most valuable natural resource: the estuarine ecosystem.

Except for the San Francisco Bay Conservation and Development Commission's (BCDC) jurisdiction over a narrow shoreline band along San Francisco Bay, no entity possesses authority to ensure comprehensive land-use planning and regulation within the Bay Area. Furthermore, BCDC does not have jurisdiction over the diked historic wetlands that were historically part of the Bay, nor over the streams that are hydrologically connected to the estuary. A similar situation exists within the Delta region, though there is hope that the newly formed Delta Protection Commission may address some of these critical issues. Although the San Francisco Bay and Central Valley Regional Water Quality Control Boards have regulatory control over discharges to receiving waters, they do not possess authority for effectively influencing local land use decisions for comprehensive resource protection.

Section 404 of the Clean Water Act (CWA), administered by the U.S. Army Corps of Engineers and the U.S. Environmental Protection Agency (EPA), is the key regulatory tool for managing wetlands of the Bay/Delta estuary. However, this authority does not contain provisions necessary for halting the disintegration of the wetland resources or a mechanism for restoring the functions and values of wetlands required by the estuarine ecosystem. Major shortcomings of the 404 program include:

- The federal wetlands delineation method results in the jurisdictional exclusion of critical wetlands types (e.g., seasonal wetlands totaling approximately 470,000 acres).
- Unregulated activities such as the discing of soil and the removal of vegetation, plus illegal alterations, are adversely affecting wetlands.
- The federal wetlands program is not coordinated with local entities that govern land uses; this contributes to confusion and delays for the development community without ensuring comprehensive protection of wetland habitats.

Integrating Resource Protection and Land Use Management

The San Francisco Estuary Project (SFEP) was established under the National Estuary Program (NEP) through section 320 of the 1987 CWA. It was charged with developing a plan to restore and maintain the chemical, physical, and biological integrity of the Bay/Delta estuary. The Estuary Project is now nearing completion of a Comprehensive Conservation and Management Plan (CCMP), "a blueprint for restoring and maintaining the health" of the Bay/Delta estuary. The CCMP represents the culmination of a unique partnership between the environmental community, the public, business and industry, and all levels of government. It is the first-ever comprehensive plan designed to improve resource protection throughout the region. The CCMP represents a commitment to coordinate efforts "to achieve and maintain an ecologically diverse and productive natural estuarine system." The heart of the CCMP consists of approximately 150 actions. The actions are organized into the following nine CCMP programs areas:

- Aquatic Resources
- Wildlife
- Wetlands

- Water Use
- Pollution Prevention and Reduction
- Dredging and Waterway Modification
- Land Use
- Public Involvement and Education
- Research and Monitoring

The CCMP land use actions are designed to improve management of the lands surrounding the Bay/Delta estuary. The actions recognize the importance of integrating management of the estuary with the existing functions of state, regional, and local governments. They call for the initiation of watershed planning across the region and the implementation of innovative land use practices that are geographically targeted, locally tailored, and cost-effective, and they reflect the need to protect and enhance estuarine resources while helping to promote economic prosperity (SFEP, 1992).

The land use actions primarily rely on utilizing existing institutional mechanisms to improve the efficiency and effectiveness of land use decision-making through improved regional cooperation (Figure 1). This includes amending state laws and policies to integrate estuarine planning with major statewide initiatives such as growth management and the protection of biodiversity. Through utilizing existing regional entities or new regional entities such as the Delta Protection Commission, growth could be guided to appropriate areas, research could be conducted concerning future population scenarios, and natural areas critical to the functioning of the estuarine ecosystem could be identified and safeguarded. In addition, the CCMP recommends actions to provide local government with adequate financial and technical support and to establish economic incentives for private-sector resource protection.

Demonstration Projects for Watershed Protection

To emphasize implementation, the NEP encourages early implementation of key actions through demonstration projects. This is particularly important since the authority to implement the CCMP is weak and ambiguous. While section 320 of the CWA states that the CCMP "shall be implemented" it provides no authority to enforce implementation. In September 1992, SFEP established a network of demonstration projects to:

- Institutionalize management arrangements that provide momentum for maximum implementation of the CCMP.
- Achieve direct environmental improvements.
- Help establish a comprehensive watershed protection approach for the Bay/Delta estuary region.
- Enhance technical transfer and

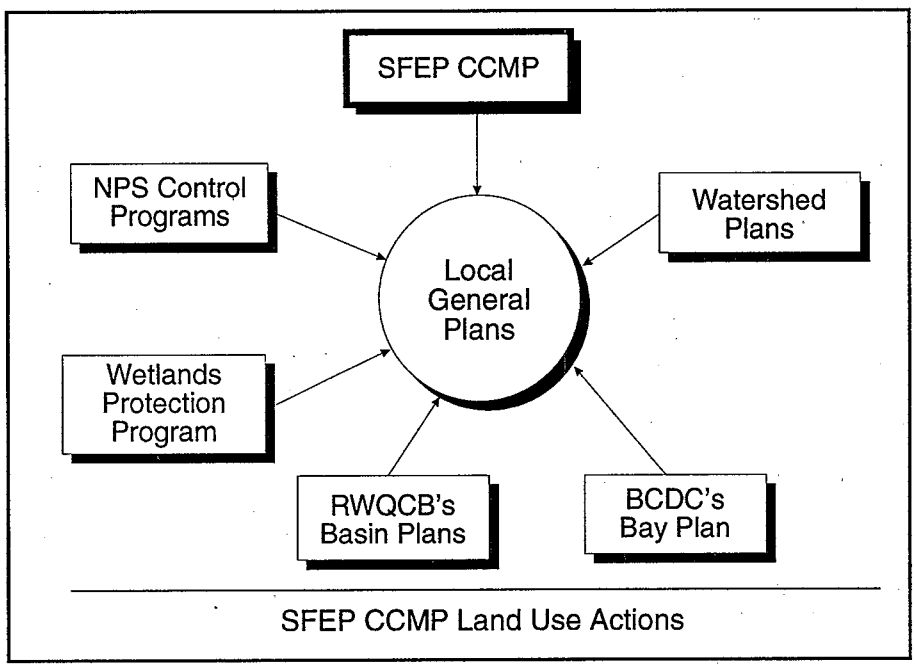

Figure 1. Model for integrating estuarine protection efforts with existing local land use management. CCMP land use actions are identified to (1) develop General Plan Guidelines for estuary resource protection and corresponding ordinances for implementation, (2) include resource protection goals in state growth management and regional biodiversity initiatives, (3) improve land use practices through education, and (4) provide local government with adequate financial support and economic incentives for implementation.

coordination of existing watershed management efforts (e.g., creation of a geographic information system (GIS), environmental monitoring, etc.).

- Demonstrate methods for risk-based geographic targeting by identifying the small stream tributaries of the Bay/Delta estuary that perform important ecosystem functions, including the maintenance of biodiversity.

Researchers have identified the boundaries for approximately 30 hydrologic units within the 12-county Bay/Delta region (Blanchfield, 1992). These hydrologic units and the small stream tributaries contained within them provide the focus for watershed management efforts throughout the Bay/Delta estuary. Often overlooked, these small stream systems shelter some of the estuary's last remaining populations of wild fishes. Following a consensus-based process where project proposals were entertained and screened by multidisciplinary panels, the following network of demonstration projects for watershed protection were selected:

1. Identifying and selecting priority aquatic sites for designation as aquatic diversity management areas (ADMAs).
2. Initiating a regional monitoring strategy.
3. Creating a GIS data base for the Bay-Delta region.
4. Improving the management of livestock grazing on public land.
5. Citizen monitoring of urban streams.
6. Integrating riparian restoration with the conservation of farmland.
7. Designing institutional arrangements for CCMP implementation.
8. Developing best management practices (BMPs) for agricultural drainage.
9. Controlling erosion on vineyards damaged by phylloxera.

Identifying and Selecting Priority Aquatic Sites for Designation as ADMAs

The CCMP recommends identifying the least disturbed, and most jeopardized, stream habitats for the purpose of designating ADMAs to improve the stewardship of land and water resources (SFEP, 1993). Establishing a system of ADMAs would require careful diplomacy with landowners and local government, and could serve as a key protection tool for watershed management as outlined in the CCMP land use actions.

Researchers from EPA and University of California (UC)-Berkeley began this project by reviewing historical data on the distribution of native fishes. After a number of streams were screened, approximately 36 drainages were selected for further study. Additional surveys will better characterize the distribution of fishes while providing data on aquatic habitat parameters and the condition of riparian vegetation. Criteria will be developed for determining whether a drainage would be a suitable site for the establishment of an ADMA. If a drainage meets the criteria, researchers will prepare a rationale to support ADMA designation.

Initiating a Regional Monitoring Strategy

This project supports efforts already underway to implement CCMP actions related to improving monitoring and research efforts. Pilot projects are being developed to test the design of long-term monitoring programs for wetlands, wildlife, and land use.

Creating a GIS Data Base for the Bay-Delta Region

Researchers from UC Berkeley are augmenting the existing regional GIS to provide data that will improve the scientific basis for making decisions for CCMP implementation. The GIS focuses on adding data layers, increasing system capabilities for data sharing and output, emphasizing collaboration with all levels of government and private organizations, and advancing data analysis and modeling. This project will perform "umbrella" GIS services for the other demonstration projects.

Improving the Management of Livestock Grazing on Public Land

The Contra Costa Resource Conservation District is assisting a rancher with developing a grazing management strategy for a 500-acre parcel of public land within Wildcat Creek Regional Park. Barriers are being built to prevent livestock from trampling sensitive headwaters habitat.

Also, pens are being installed so that livestock can be intensively managed through rotational grazing. Grazing periods will be selected to disrupt the growth of alien plants and to favor the reemergence of native bunchgrasses and forbs. These measures are designed to result in the growth of more desirable forage, an increase in the abundance and diversity of native flora, a decrease in soil erosion and pollutant loadings into Wildcat Creek, and a model for public/private partnerships in watershed protection.

Citizen Monitoring of Urban Streams

The Coyote Creek Riparian Station is training volunteers to survey water quality conditions and the flora and fauna of selected urban streams in Santa Clara County. Here, citizens are using EPA-approved protocols for developing a data base describing creek conditions; a *Status Report of Santa Clara County Creeks* that will be considered by the city of San Jose and Santa Clara County in preparing their respective General Plans; a *Creek Care Guide* for industrial, commercial, and residential entities; and a model process for using citizens characterizing and protecting sensitive aquatic sites throughout the Bay-Delta region.

Integrating Riparian Restoration with the Conservation of Farmland

The Nature Conservancy, in conjunction with Sacramento County and Ducks Unlimited, is developing an integrated conservation and restoration plan for the 560-acre Desmond Ranch parcel contiguous with the Cosumnes River Preserve. The plan will result in the expansion of rare valley oak riparian forest and seasonal wetlands on one portion of the property; the remainder will be set aside as an agricultural preserve. This project is designed to demonstrate the compatibility of conservation biology and agriculture.

Designing Institutional Arrangements for CCMP Implementation

This project assists with the design of institutional arrangements that could help ensure the long-term implementation of the CCMP and overall watershed protection.

Developing BMPs for Agricultural Drainage

The California Department of Pesticide Regulation is coordinating with the West Stanislaus Resource Conservation District to develop BMPs to control the discharge of pollutants in agricultural drainage. This project could yield techniques that could be applied in other watersheds of the Central Valley. It will employ GIS to integrate critical data and to assist in the development and evaluation of site-specific BMPs.

Controlling Erosion on Vineyards Damaged by Phylloxera

The Sonoma County Resource Conservation District is working with local farmers to develop a guidance manual that can be used to control soil erosion during the replanting of vineyards. Grape rootstocks throughout this major wine-making region are being damaged by the pest known as phylloxera "B." This project, if properly integrated with EPA's North Bay Initiative, could establish momentum for enlightened management of the Sonoma Creek watershed.

Conclusion: Watershed Management Should Be a Focal Point for Integrating Land Use Decisions and Resource Protection

Current interest in watershed management reflects a growing consensus that existing water quality problems can be effectively addressed by a more integrated, basin-wide approach. The CCMP proposes a flexible framework for integrating current environmental efforts, and for exploring innovative methods to sustain natural resources and their beneficial uses. Also, the CCMP takes an important step toward a strategy for watershed management throughout the Bay-Delta region.

While laudable, the demonstration projects described above are only a modest start. Real watershed protection awaits the establishment of an institutional framework that integrates federal and state resource protection with local land use planning. We are not advocating that the federal government be given new authority to regulate land use. Rather, we are urging better coordina-

tion and integration of various governmental functions to maintain sustainable ecosystems within an increasingly urbanized environment. The following recommendations should be considered:

- Revisions should be made to the CWA to improve wetlands protection, encourage comprehensive watershed management, and facilitate the integration of resource protection with local land use policies. Emphasis should be placed on achieving sustainable ecosystems and economies. In addition, amendments should be made to section 320 to provide the authority and funding needed to ensure implementation of CCMPs.
- In California, federal, state, and local agencies should integrate local land use decisions with growth management goals and watershed protection initiatives.
- Federal and state resource agencies should provide technical and policy assistance to local governments to better mitigate for environmental damage related to past land use activities and to help direct future growth to promote resource protection, government efficiency, and economic prosperity.
- For critical resource areas such as the Bay/Delta estuary, watershed management plans should be prepared and implemented for all the hydrologic units.

Extraordinary measures are now required to restore a sustainable estuarine ecosystem. From Sacramento to San Francisco, our resolve to provide ongoing stewardship for the Bay/Delta estuary can demonstrate that environmental protection and economic prosperity can be successfully linked. This endeavor will likely be one of the greatest challenges as we enter the new millennium and will challenge our beliefs concerning private property rights, individual responsibility, legal powers, regulatory limits, and scientific uncertainty.

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The Brandywine: Managing a Watershed in an Urban/Rural Environment

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Background

Water supply and hydropower demands of the 19th Century industrial revolution brought significant land use changes along the banks of the Brandywine Creek, supplanting historic agricultural practices in those areas. With the advent of steel and paper producers in the watershed, rapid population growth was also experienced, placing additional stress on the water resources of the basin.

The headwaters of the Brandywine rise in Chester County, PA, which contains 83 percent of the watershed, draining southward through New Castle County, DE, and eventually through the Christina River to the Delaware Estuary.

Existing land use identifies the area as urban/rural with commercial, limited industrial, residential, and high technology activities co-existing with long-standing agricultural uses. The county has an active agricultural preservation program which seeks to maintain this balance for the future.

In the 1930s, local sportsmen's groups brought focus to the degradation of Brandywine waters and commenced an educational campaign to reverse the trend. Recognition of the need to preserve in-stream uses and improve water quality also attracted the attention of other individuals, groups, and governmental representatives. In 1945, the Brandywine Valley Association was formed, the first small watershed group of its kind in the Nation.

That organization, an increasingly-effective group today, was responsible for initial limnological investigations of the Brandywine and later was instrumental in the study of water supply and flood control issues required to manage the system. Through the efforts of the interstate association, the Chester County Water Resources Authority (WRA) was created by the Board of Commissioners in 1961 to implement the recommendations developed in the study and undertake new programs which have evolved over the past three decades.

Water Supply/Flood Control

In 1962, the Brandywine Watershed Work Plan received congressional approval and work was begun on a series of structural measures to avoid repetition of the droughts and floods previously experienced in the basin. The WRA was assigned responsibility as local sponsor to work with the Soil Conservation Service (SCS) in implementing the plan elements. With major participation by the Commonwealth of Pennsylvania, the Marsh Creek Reservoir was completed in 1975. It provides water supply for Chester County communities, flood control for downstream interests, conservation releases to protect in-stream uses, and recreational benefits in the new state park surrounding the facility.

At the same time, work proceeded on three other structures on the East Branch Brandywine, including a facility in cooperation with the Pennsylvania Fish and Boat Commission and two other flood control projects with the last completed in 1983. Operating in series, these four facilities provide significant flood peak reduction at

the Downingtown damage center and 13.5 million gallons per day in water supply.

Construction is now underway on another multipurpose project on the West Branch Brandywine. This project will provide water supply for the Coatesville area, flood control to reduce peak flows downstream, a conservation release which will stabilize flows in the receiving stream, and the first water-based recreational facility within the county park system. As with all the structures under the Brandywine Watershed Work Plan authorized under P.L. 566, an accelerated program of land treatment above the facility is mandated. However, the process is not new to Chester County. Since the creation of the county's Conservation District in the 1950s, an active land conservation program has been pursued with local agriculturists.

The operation of the water supply aspects of the reservoir system takes into account in-stream uses and the needs of downstream interests. Under an operational plan developed for the Delaware River Basin Commission, compensating releases for consumptive use makeup are mandated during periods of low flow to provide adequate water for the city of Wilmington, DE. The downstream community also benefits from the peak flow reduction incorporated in the flood control aspects of the work plan.

The Brandywine Plan

An active program to protect the quality of Brandywine waters saw its beginning with the development of The Brandywine Plan by the University of Pennsylvania through a Ford Foundation grant administered by WRA. The study focused on the Upper East Branch of the Brandywine and with its publication in 1968 advocated the acquisition of conservation easements along the waterway. It also recommended active soil erosion and sediment control measures for new development through local ordinances. Even though the purchase of conservation easements was not embraced by local municipalities, the Brandywine Conservancy has actively pursued a voluntary program with marked success. Soil erosion and sediment control measures have been emplaced as a result of activities by the Chester County Conservation District in administering state requirements.

The Brandywine Plan also recognized the need to restrict building in the floodplain; and with the passage of time, local municipalities have adopted ordinances that ban such development. The success of this approach is particularly notable during flooding events when additional storage is available as a result of floodplain preservation.

The Plan also stimulated other activities which have led to improved management of the Brandywine Watershed. During the study phase, emphasis was placed on the need for a data collection system which included precipitation, ground-water availability, stream flows, and chemical and biological quality. The involvement of the U.S. Geological Survey (USGS) in the 1968 Brandywine Plan forecast the cooperative program with the WRA of today.

USGS Cooperative Program

In 1969, the WRA established a long-standing working relationship with USGS under the cooperative program through the initiation of limnological studies on the major streams in the county. Twelve of the 44 sampling sites are located within the Brandywine Watershed. A major goal of the project is a further understanding of stream changes in response to urbanization and incorporates benthic invertebrate investigations along with chemical sampling and stream discharge at the time of sampling. The original effort was conducted on a quarterly basis, but has evolved over time to annual low flow investigations. A statistical approach has now been developed which provides a trend analysis updated on an annual basis and depicts improvement in the county's streams since 1969. This upward trend reflects the effectiveness of investment in upgrading of municipal and industrial waste treatment capabilities, implementations of soil erosion and sediment controls, and improved land treatment practices by the agricultural community.

In 1972, the immediate focus of the cooperative program shifted to ground water. Chester County is in the Piedmont Province of the Appalachian Highlands underlain by crystalline rock. A narrow band of limestone and dolomite bisects the Brandywine in the center of the county.

Water supply is extracted from fractures in the rock and an understanding of the system was necessary to establish base flow contribution of ground water and establish a water budget for the county. Upon completion of the study in 1975, it became evident that the precipitation data collection system and ground water level monitoring network established for the project would merit continuation. Evolving from that process is today's volunteer rain gage network of 34 stations as well as establishment of recording rain gages on data collection platforms located on the Brandywine. The groundwater-level monitoring network has been expanded to include the major aquifer systems in the county.

Water Resources Inventory

Throughout the first decade of the USGS/WRA cooperative program, substantial data were developed to provide increased understanding of the meteorologic, hydrologic, and geologic systems affecting the county's water resources. An evaluation of these data, including information regarding floodplains, soil erosion and sediment control, and the county water budget, demonstrated a need to present these elements in a form which would be useful to municipal officials having responsibility for land use decisions. WRA, in cooperation with the Chester County Planning Commission, embarked on a 2-year project in 1978 which would convert the information into a layman's guide to water resources management.

The resulting publications, including the *Brandywine* published in 1979, served as an educational tool for municipal decision-makers and established a series of scenarios based on current and projected zoning densities. These scenarios established a preliminary water budget analysis for that portion of the studied watershed occupied by the host municipality. The scenarios also alerted the municipal official to water quality issues when the receiving stream for sewage effluent discharge neared its assimilative capacity.

The Water Resources Inventory has been refined over time and led to the creation of a two-dimensional flow model of the crystalline rock by USGS which can simulate the effects of development proposals on ground water and base flow in a specified area. That model has been placed on the computer system of West Chester University for use by consultants and the academic community.

Innovative Management Techniques

The ongoing WRA/USGS cooperative program has resulted in a number of innovations designed to enhance management of the Brandywine and other watersheds in the county.

Substantial data have been generated since 1972 from the monitoring well network, where levels have been recorded on a monthly basis. In order to better understand the response of the system to precipitation events and the impact of withdrawals, a statistical approach was developed to determine the point at which levels would approach a drought watch, warning, or emergency stage. The system is now in place and functions as a key element in all drought response activities and assists in the evaluation of any reports of abnormal decline in a localized area.

In the course of evaluating the location of proposed SCS structures on the West Branch Brandywine dating from the 1962 Work Plan, USGS was called upon to develop a storm water management model which refined earlier hydrologic investigations and contributed to the establishment of the final cost-benefit ratio analysis. Through precipitation event simulation, projected flood peak reductions were determined which aided in the final design of the project currently under construction.

Water quality, stream flow, and precipitation data collection are aided by the installation of three data collection platforms on the Brandywine. Strategically located on the East and West Branches and the main stem, the platforms provide real-time access during flooding events to project time and height of flood crests and react similarly when determining low flows during drought. Recording rain gages associated with the data collection platforms enable establishment of long-term records for storm water management design while at the same time assisting flood forecasters by recording rainfall intensity. The water quality probes covering pH, dissolved oxygen, temperature, and dissolved solids aid in evaluating spill events and provide a permanent record on a hourly basis for review of long term trends.

The information from the data collection platforms is retrieved by satellite and discharged to a USGS receiving station at Harrisburg, where the information becomes directly available to the WRA by computer downlink.

The quality of ground water in the Brandywine Watershed continues to be a significant concern for public water purveyors and individuals withdrawing their supply from the system. In cooperation with the Chester County Health Department, a joint ground water quality assessment program is now entering its ninth year. USGS personnel obtain 45 samples each summer from those areas where the mishandling of toxics by man may be expected to create a problem. The samples are evaluated for all priority pollutants, including herbicides, pesticides, and radionuclides. The program has been instrumental in defining the two Super Fund sites identified in the Brandywine Watershed.

Evolving from this process has been a ground water contour mapping program which has been produced on a workable scale to enable predication of movement of the resource through the system. The mapping effort is also a valuable working tool in development of wellhead protection programs.

One of the innovative management efforts which has evoked considerable interest by state and local agencies during the past year is the water budget analysis program developed under the WRA/USGS cooperative program. Using a previously-created water use data management system containing information on withdrawals, discharges, importations, and exportations form the county, the program was refined and a model developed for watershed budgets. This provides realtime assessment of ground water reserves and base flow of the stream in a wet year, dry year, or normal year. The water budget can be used to evaluate impacts on the resource resulting from land use changes, water withdrawals, and allocations. It is also useful in defining those watersheds which may already be stressed due to overallocation of surface and ground water.

Interstate Management Initiatives

Initial interstate regulatory oversight of the Brandywine Watershed was first put in place with the passage of the Delaware River Basin Compact in 1961. However, more localized initiatives commenced with a series of meetings between regulatory and policy personnel from the Commonwealth of Pennsylvania and the State of Delaware in 1972. This effort led to the formation of the Brandywine Task Force, an informal group meeting quarterly under the auspices of the Brandywine Valley Association to discuss issues relating to water quality and quantity in the watershed. Representation comes from the public and private sector, including the two states.

The drought events of 1980-81 and again in 1985 also led to the creation of the Christina River Basin Drought Management Committee which includes the Brandywine as well as the Red and White Clay Watersheds.

Participants include the two states, the two counties, and water purveyors from both jurisdictions who jointly developed a drought response program for the Christina Watershed. This interstate cooperative effort provided timely and effective drought response during the past year.

A new management approach is currently in its infancy in the Brandywine Valley. Under the auspices of the Delaware River Basin Commission and with the cooperation of the U.S. Environmental Protection Agency, the two states and the WRA are involved in initial steps which will lead to the development of the Total Maximum Daily Load (TMDL) program for the Brandywine. Innovative water quality modeling and institutional arrangements for the TMDL program are expected to be vital constituents of the process.

Management of the water resources of the Brandywine Watershed, set in an urban/rural environment, continues to be an evolving process. The WRA, the only agency of its kind in Pennsylvania, will continue to play an important role.

A Blueprint for the Future: Tradable Emissions Permits for the Regulation of Agricultural Drainage in California's Central Valley

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For over a decade, the problem of effectively controlling drainage discharges from irrigated agriculture (one form of agricultural nonpoint source pollution) on the west side of California's San Joaquin Valley has challenged and frustrated regulators, farmers, and environmentalists alike. There is no doubt that drainage discharges have caused and continue to cause significant environmental damage. Yet, despite a broad consensus that substantial progress can be made toward solving the problem using available and affordable irrigation technologies, success in actually implementing these technologies and solving the problem has been elusive.

In several important respects, the challenges to successful control of agricultural drainage in the San Joaquin Valley are representative of the problems of agricultural nonpoint source pollution control nationwide. According to the U.S. Environmental Protection Agency's (EPA) most recent National Water Quality Inventory (USEPA, 1988), agricultural runoff is the most significant source of water quality problems in water quality-impaired rivers, streams, lakes, and estuaries across the United States. And, like most nonpoint source pollution problems, agricultural drainage flows are composed of dozens of independent, variable sources and thus can be difficult to monitor and control.

For these reasons, the traditional permit-oriented approach to pollution control seems cumbersome for agricultural nonpoint source pollution and has thus far been rejected by state and local regulatory agencies. On the other hand, the imposition of "best management practices" (BMPs), the version of command-and-control environmental regulation generally applied to nonpoint sources, for drainage management presents its own set of shortcomings.

This combination of factors—a significant, uncontrolled source of environmental pollution and imperfect regulatory tools for controlling it—has given rise to a growing recognition among policy makers and regulators of the need to identify cost-effective control strategies for agricultural pollution. At the same time, public and private concerns over the costs and administrative burden of environmental regulations have intensified interest in alternative, market-oriented approaches for protecting environmental quality.

The potential advantages of incentive-based regulatory programs—cost-effective pollution control, maximum flexibility to the regulated community, and reduced informational and bureaucratic requirements for regulators—have been widely discussed in the literature and policy-making arenas. Incentives also have been used in conjunction with traditional technology-based controls in a limited number of air and water pollution control programs. However, incentives have rarely, if ever, been considered as the primary means of pollution control, or in a context where pollution problems are solely due to nonpoint sources.

With this in mind, the Environmental Defense Fund (EDF) has investigated the advantages, disadvantages, and feasibility of using economic incentives in general, and tradable discharge permits in particular, to regulate pollution from irrigated agriculture in California's San Joaquin Valley.

The Drainage Problem

In the 92,000-acre area of the San Joaquin Valley of California known as the Grasslands, drainage from irrigated agriculture poses significant environmental problems. Here, naturally occurring toxic trace elements (including selenium, boron, arsenic, and molybdenum) and salts are mobilized and transported in the subsurface drainage water as a result of irrigation. Drainage management practices in this region have resulted in extensive degradation both to local riparian and river habitats, and also to the valuable regional wetlands.

The principal solution to this problem lies in improved irrigation management at the individual farm level, combined with limited operational changes at the water district level. However, while this solution may be clear, the road to implement it is not. To date, the state has relied upon voluntary cooperation by farmers and water districts for meeting water quality objectives. This "regulatory program" lacks a meaningful mechanism for assessing compliance, sidesteps the issue of enforcement, and appears unlikely to be successful in meeting water quality standards. Therefore, a shift to nonvoluntary regulatory options appears necessary.

Designing a more formal regulatory system for the Grasslands is made easier because several key elements of a regulatory program already are in place. First, the existing authority and jurisdiction of water and drainage districts provide the basic institutional structure for an accountable system of pollution control. Second, California has adopted water quality standards for surface waters in the Grasslands region, and has the authority to issue permits for agricultural dischargers. Third, the physical boundaries and processes of pollution generation and discharges are fairly well understood: pollution is produced as a by-product of irrigation on all farm lands, and is subsequently collected in subsurface sumps and surface drainage ditches which ultimately discharge into the San Joaquin River. Finally, district drainage outputs are currently being monitored (and farm-level outputs are monitored in some districts), and farm-level water inputs can easily be monitored as a surrogate for drainage outputs.

In order to succeed, a regulatory program will have to address a number of complicating factors, including determination of the appropriate method for defining the total allowable pollution load; equity problems among entities to be regulated (districts and/or farms) due to downslope subsurface migration of drainage; lack of drainage output monitoring at the farm level; the historic lack of farm-level accountability for drainage generation; and limited economic resources of agricultural community for costly abatement options.

Defining the Goal

The first step in any water pollution control program is to identify the environmental goal to be met, generally a concentration-based water quality standard. In water-quality impaired waterbodies, states are required to calculate a total maximum daily load (TMDL) to establish the assimilative capacity of the waterbody for a specific pollutant, taking into account discharges from point sources, nonpoint sources, natural background sources and a margin of safety to account for scientific uncertainty or potential future discharges. In cases where information about the waterbody, pollutants, the effectiveness of control actions, or other factors, is limited, a TMDL may be implemented in phases.

Water quality in the middle reach of the San Joaquin River currently exceeds selenium standards, with agricultural drainage accounting for 90-95 percent of the selenium load (Kratzer et al., 1989). Calculating a TMDL for selenium discharges from the Grasslands subbasin is complicated by the fact that the San Joaquin River, like many western rivers, is characterized by dramatically fluctuating and minimally predictable flows which often are effluent-dominated. Effluent flows also are highly variable due to hydrologic and management conditions. As a result, the standard TMDL statistical approach is inappropriate. In response to these conditions, a simple calculator TMDL model in spreadsheet format was developed to account for seasonal and

water year type flow variations. (Karkoski et al., 1993.)

The model developed for this study differs from the standard TMDL methodology by (1) translating a 4-day low flow into monthly time steps consistent with implementation constraints; (2) grouping the flow record according to irrigation seasons and water year types to account for flow variations; and (3) using historic flows to determine the applicable design flow and TMDL. The spreadsheet model also accommodates modifications to account for changing environmental conditions or policy objectives. The results of the TMDL analysis indicate the need for a 77 to 89 percent reduction in drainage-related selenium loads from the Grasslands region from 1988 levels, depending on the year-type, based on current EPA standards.

Regulatory Options Including Tradable Permits

No single regulatory approach will be appropriate for all pollution problems. However, the magnitude and persistence of remaining water quality problems, particularly those due to nonpoint sources, require a broader look at regulatory measures that are capable of not only controlling pollution discharges but also reducing pollution at the source.

In this study, EDF compared incentive-based and command-and-control programs for reducing and controlling agricultural return flows in the Grasslands. The incentive-based approaches examined include effluent fees or pollution taxes, marketable permits, and input pricing. The command-and-control options reviewed include mandatory BMPs and permits. These options were compared based on the following criteria: compatibility with the regulated community, cost-effectiveness, ability to achieve the environmental objective, equity, monitoring and enforcement, and ease of administration.

Briefly summarized, a system of BMPs is likely to be inferior to an incentive-based approach for regulating agricultural return flows because of the lack of information on the large number of factors (e.g., costs, environmental constraints, and management techniques) which affect actual irrigation efficiencies at the farm level and is necessary for determining the appropriate BMP. A BMP system will tend to be expensive because all farmers will face the same requirements regardless of differences in pollution control costs, and because technological requirements must be stringent enough to account for differences in management techniques. Once in place, BMPs do not guarantee that the pollution target will be met because actual performance depends as much on the control technology as on how it is used, and because mandatory BMPs provide little inflexibility for responding to variations in pollution objectives, market conditions, and other changes. Moreover, farmers are likely to oppose a mandatory BMP program because they would object to regulators "telling them what to do."

By contrast, incentive-based systems offer greater potential for achieving the pollution target in a cost-effective manner. Incentives are more *compatible* with the characteristics of the agricultural community. They encourage compliance and innovation by allowing decentralized decision making on pollution control options. Effluent fees, input pricing, and trading systems rely on market signals (e.g., prices) to internalize pollution costs, thereby encouraging farmers to pursue least-cost options for controlling pollution. Unlike BMPs, incentive-based systems take advantage of cost differences, and other nonmarket differences, among farmers and rely on the market to bring about a *cost-effective* distribution of pollution control responsibility (i.e., where the marginal costs of pollution control are equal for all farmers). Differences in management and performance are addressed by focusing on outputs (emissions fees, tradable discharge permits) or production inputs (water pricing). Incentives also allow farmers to alter pollution control practices in the face of changes in the drainage allocation from year to year, technological innovations, crop contracts, or other factors.

Effluent fees, input pricing, and marketable discharge permits can all *achieve the desired pollution objective.* Effluent fees and input pricing will effectively achieve specific targets only if rates are high enough. However, iterative attempts to "fine tune" the fee structure to achieve desired loading levels, or to respond to changes in river flows, could result in opposition from the regulated community and add to delays in meeting the pollution goal. In the Grasslands, meeting the pollution target is critical given the toxicity

and bioaccumulative potential of selenium. This argues for a system of tradable discharge permits which entails designating a specific pollution "cap" to guarantee that the target will be met.

While BMPs may appear *equitable* because they require all farmers to do the same thing, effluent fees, input pricing, and tradable discharge permits are designed to equalize marginal pollution control costs among all farmers through a pollution cost (in the case of effluent fees or input prices) or permit price (in the case of tradable permits). Tradable discharge permit systems also can be tailored to address specific problems of equity among regulated farmers or districts (e.g., to compensate farmers who previously invested in pollution control measures), and serve as a means of cost-sharing on a regional basis.

In terms of *verification,* the need for effective enforcement, backed up by accurate monitoring, is a challenge for any program focused on nonpoint source pollution control. Unlike BMPs, incentive programs do not require monitoring of specific practices for achieving a desired objective. Instead, compliance is measured relative to the ultimate pollution goal, rather than the means for achieving the goal. In the Grasslands, district drainage outputs are currently being monitored (and farm-level outputs are monitored in some districts), and farm-level water inputs can easily be monitored as a surrogate for drainage outputs.

The study finds that a system of tradable discharge permits, based on economic incentives rather than on traditional regulatory permitting concepts, may be ideally suited for addressing the prevailing problems of agricultural drainage management in the Grasslands subbasin. Here's how it would work. First, because current concentrations of drainage constituents (e.g., in this case, selenium or boron) exceed water quality standards, an overall reduction in the current pollution load in the subbasin would be required. Once the total allowable load has been determined, the portion attributable to agricultural return flows would be allocated among the individual water districts in the Grasslands. (In the Grasslands, the allocation at the district level is necessitated by the fact that discharges are directly monitorable at the district level, while farm-level monitoring would require substantial improvements in the existing drainage management system.)

The Regional Water Quality Control Board (or alternatively, a Regional Drainage District) would assign permits to the irrigation districts; each permit would specify an *initial* load allocation for a given pollutant at a given discharge point. The initial allocation formula could address various equity concerns of the farmers, and might be based on a variety of factors, including acreage, cropping pattern, and past drainage performance. (District allocations also could serve as the basis for emissions targets under a system of district-level effluent fees, or as effluent limits for a permit program.)

On the basis of this initial allocation, permit holders could trade (buy and sell) portions of their allocations to other districts, just as shares of stocks are bought and sold on the open market. (The "market" may be operated by the regulatory agency or by a designated third party, such as a regional district.) Each district would be held responsible for meeting the adjusted pollution allocation, which is the initial allocation plus or minus any trades, and district-level drainage outputs could be monitored directly. Similar, albeit informal, water trading already occurs among water districts.

A system of tradable discharge permits, and any regulatory program designed to decrease agricultural return flows, ultimately must address farm-level practices, regardless of whether the regulatory responsibility is vested at the regional or farm level. In the Grasslands, the farm-level allocation, whether established on the basis of drained acreage, irrigable acreage (drained and undrained), or other criteria, would provide the informational basis for districts involved in a trading system to "pass on" to their farmers the responsibility for pollution abatement consistent with market transactions. The method for creating this accountability at the farm-level may vary among districts, but should consist of incentive programs such as tiered water pricing, effluent fees, compensated land retirement, and cost-sharing for irrigation improvements. Districts have an incentive to adopt an effective program once each is held accountable for meeting a specific pollution allocation.

Other issues of implementation, market structure and operation, administration and information-sharing, and enforcement also would be addressed in the final design of a tradable discharge permit system.

Institutional Accountability

An essential aspect of any program to regulate agricultural return flows is assigning responsibility for pollution control to polluters. In the case of the Grasslands, a system of tradable discharge permits would appropriately shift the burden of drainage control to water districts and farmers, and at the same time, would spare state and local agencies the task of issuing and administering individual permits or BMPs. However, the success of this approach, or any regulatory program, requires unambiguous lines of authority regarding the legal status of the regulatory instruments, regional-level reporting and enforcement responsibility, and farm-level accountability.

In the Grasslands, this need for accountability is best satisfied at the regional level. EDF investigated the legal and institutional basis for creation of a regional entity (e.g., Regional Drainage District, independent third party, a joint powers authority, or a local authority) to oversee, facilitate, and help enforce a system of tradable discharge permits among water districts, taking into account the role and jurisdiction of existing agencies in the Grasslands region. The role and powers of the regional entity (e.g., regulate and enforce drainage practices, levy fees or assessments) would enable it to act in cooperation with, or in lieu of, the districts in establishing farm-level accountability. The proposed regional drainage district provides a template for the formation, authorization, and incorporation of a regional entity to serve as a blueprint for other agricultural regions.

Conclusion

Tradable discharge permits are not a panacea for every nonpoint source problem, but the system is particularly attractive for the Grasslands subbasin. Because the physical, economic, and institutional characteristics of the subbasin have been extensively studied, most of the informational and regulatory components of a tradable permit system are already in place. The existing monitoring network can be readily adapted to serve a tradable permit system. A common drawback of tradable permits in river systems—the unequal environmental effects of pollution inputs upstream versus pollution inputs downstream—is not a factor here because the drainage is currently discharged into one localized area. In short, this system holds the promise of eliminating the irreconcilable choice between an unmanageable regulatory program and environmental protection.

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Point-Nonpoint Source Nitrogen Trading in the Stamford, Connecticut, Watershed

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A grant-funded study investigating nitrogen techniques has been initiated in Stamford, Connecticut, as part of the Long Island Sound Action Plan Demonstration Project. The study will consist of two major components. The first component, referred to here as the Biological Fluid Bed (BFB) denitrification demonstration project, will involve the operation of a full-scale reactor to test the effectiveness and cost of this nutrient removal technology at the Stamford Water Pollution Control Facility (SWPCF). The second project involves an assessment of point-nonpoint nitrogen trading for the Stamford area. This paper discusses the proposed approach for this second project, which was initiated in March 1993 and is expected to conclude in December 1993. This paper discusses the project goals, the study area, the proposed approach, and key project issues.

Funding for this point-nonpoint nitrogen trading project was derived from a Clean Water Act section 319 grant, after the Environmental Protection Agency (EPA) encouraged the City of Stamford to expand the scope of its grant application to demonstrate the BFB technology. The request by EPA to add the watershed study to the BFB study illustrates the increasing emphasis being placed by EPA and state regulatory authorities on watershed approaches and market-based approaches for meeting water quality objectives (USEPA, 1992).

The proposed approach for the Stamford point-nonpoint nitrogen trading study can be summarized as follows. Nitrogen loads will be estimated for both point and nonpoint sources in the Rippowam and Noroton River watersheds that discharge into Long Island Sound. These two watersheds encompass most of the City of Stamford, as well as the neighboring Town of Darien, and are partly sewered with treatment at the SWPCF. Given estimates of the sources and relative contributions of nonpoint source nitrogen loads in the two watersheds, control options will be assessed and removal effectiveness and order-of-magnitude cost estimated. This information will then be used to assess the feasibility of developing a point-nonpoint source nitrogen trading program in the Rippowam and Noroton River watersheds in Connecticut.

Project Objectives

The goal of this project will be to identify a cost-effective option which could be used by similar communities with watersheds discharging to Long Island Sound to help make decisions concerning nutrient loading and removal. Practical issues affecting the feasibility of implementing a system of market-incentives for nitrogen trading between point and nonpoint sources will be identified. Finally, the feasibility of reaching water quality goals

with trading of controls on point and nonpoint sources will be assessed.

Background

Long Island Sound No-Net-Increase Policy

Recent studies have determined that nitrogen is the limiting nutrient contributing to eutrophication problems (algae growth and anoxia) in Long Island Sound. In November 1990, the Policy Committee of the Long Island Sound Management Conference adopted a program to ensure "no net increase" in the loads of nitrogen discharge to the Sound by 45 wastewater treatment plants in Connecticut and New York. Connecticut has established baseline loads and permit limits based on 1990 discharge loads for 13 coastal communities. A "Nitrogen Bank" will be established which will allow statewide point source load reduction targets to be met with pollution credits being traded between point source discharges. However, targets for reductions of nonpoint sources have not been determined, pending completion of the Long Island Sound Study's Comprehensive Conservation and Management Plan.

Description of Watersheds

The Rippowam and Noroton River watersheds encompass 37.5 and 11.9 square miles, respectively, in the City of Stamford and the Towns of Darien and New Canaan, CT. The Rippowam extends north into Westchester County, NY, and includes the North Stamford Reservoir and the Laurel Reservoir, which are drinking water supplies for Stamford.

Land Use

Land uses in the study area watersheds are primarily urban (medium- and high-density residential, commercial, and industrial) south of the Merritt Parkway, and suburban (low-density residential) in areas to the north. Based on interpretation of remote sensing data from Landsat (State of Connecticut Land Use and Land Cover Inventory), the land cover in the Rippowam watershed is 48 percent deciduous forest, 24 percent medium density residential, and 12 percent high density residential and commercial, with the remainder listed as either impervious surfaces or grassed areas.

Sanitary Sewer Service Area and Septic Systems

The sanitary sewer service area of the SWPCF includes most of Stamford south of the Merritt Parkway and part of the Town of Darien. The average daily flow from the SWPCF is 24.8 cubic feet per second. The average nitrogen load in the SWPCF discharge is 244 tons per year.

The ridge areas north of the parkway are heavily wooded low-density residential areas on septic systems. Out of 44,000 households in Stamford, approximately 12,000 are north of the Merritt Parkway and on septic systems. Data from the Mianus river just west of the Rippowam suggests that nitrogen loads in baseflows are not elevated (nitrate nitrogen of approximately 1 milligram per liter (Westchester County Land Trust, 1992). Nonetheless, the possibility of septic contamination of ground water and its contribution to surface water nitrogen loads will be assessed with available data from the Rippowam and Noroton Rivers.

Hydrology

Average annual precipitation in Stamford is 49 inches, of which 29 inches typically occurs as snowfall. There are no long-term stream gauges on the Rippowam and Noroton Rivers to estimate average and seasonal flows. Steep terrain north of the Merritt Parkway and a high degree of imperviousness in the urbanized area to the south lead to significant flooding problems.

City of Stamford Organization

The Public Works Department of the City of Stamford is responsible for the sanitary sewer collection system, treatment plant, storm drainage system, road maintenance, and engineering. It shares joint responsibility with the Environmental Protection Board and Health Department for environmental compliance. The Health Department has sole jurisdiction over septic system regulations. Land use planning is a shared responsibility between the Planning Department, Public Works Department, Health Department, and Environmental Protection Board.

The Public Works Department is divided into three bureaus: sanitation, highways, and engineering. Sanitation, through the Water Pollution Control Division, has jurisdiction over the operation and maintenance of over 200 miles of sanitary sewer, 18 sanitary pumping stations, 3 storm water pumping stations, and a 20-million gallons per day secondary treatment facility and shares with the Highway Bureau responsibility for 365 miles for storm sewer.

Proposed Approach

Data Collection

Information needs for the point-nonpoint nitrogen trading study can be grouped into three categories: land features, best management practices, and institutional framework.

The land features include all the land use and land cover information required to develop a nonpoint source pollution model. The information includes data on land use, soils, topography hydrology, and water quality. Land cover data are available from the Connecticut Department of Environmental Protection's land use and land cover geographic information system (GIS), which was developed on a watershed basis using remote sensing techniques. The data base identifies 23 categories of land cover. Because of discrepancies between areas identified as deciduous forest that actually are low-density housing with septic systems, this information will have to be supplemented with land use data from the City of Stamford's Department of Planning. Land use data from the planning department are not available in GIS format. Therefore, the cost-effectiveness of developing a digital land use data base for the Rippowam and Noroton Rivers within overall project goals will have to be evaluated.

The variety of technologies and management practices referred to as best management practices (BMPs) is extensive. The pollutant removal effectiveness and cost of BMPs are now recognized as site-specific and uncertain (USEPA, 1992). The goal of the Stamford point-nonpoint nitrogen trading study will not be to determine the most appropriate BMPs for the Rippowam and Noroton watersheds. Rather, available literature on BMP effectiveness and cost will be used to determine planning level performance and cost data for the Rippowam and Noroton River watersheds (Griffin, 1992). As has been done in other point-nonpoint nitrogen trading studies (Tar-Pamlico, 1992), the uncertainties in the nonpoint source loads and control effectiveness estimates will be recognized upfront and addressed by including trading ratios of more than 1-to-1 exchange of nonpoint to point nitrogen load reductions.

Finally, data collection efforts will focus on identifying existing agencies involved in managing point and nonpoint sources in the Rippowam and Noroton watersheds. Information will be collected about these agencies to permit an assessment of institutional needs for administering a possible nitrogen trading program.

Development of a Nonpoint Source Planning-Level Model

Two methods of estimating nutrient loads to Long Island Sound will be evaluated. The one most appropriate for the scope and purposes of the study will be used. The two methods to be considered are the Generalized Water Loading Functions model developed at Cornell University and a spreadsheet model.

The spreadsheet model may be an adaptation of the tool developed with EPA funding by the State University of New York and described in the report *Effectiveness of BMPs in Reducing Urban Nonpoint Sources of Nitrogen to Long Island Sound*, or a new model, depending upon the data base, model capabilities, and other factors.

The model selected for use will not be calibrated per se but results will be compared to available data from the Rippowam and Noroton Rivers with model adjustments made as appropriate.

Determination and Comparison of Nitrogen Loads

Output from the model and from the evaluation of data at the SWPCF will allow estimation of monthly and annual point and nonpoint source nitrogen loads. Using these load estimates, an initial evaluation of the relative importance of point vs. nonpoint nitrogen loads will be made.

Assessment of Nonpoint Source Nitrogen Control Options

Potential control technologies will be reviewed with consideration to their relative

costs and effectiveness. An assessment of the control options, costs, pollutant control benefits, programmatic, and other nontechnical factors will be used to evaluate the feasibility and potential for nitrogen pollution control trading in an urban setting. This task will include a workshop in Connecticut to discuss potential nutrient control options and preliminary load estimates.

Assessment of Institutional Framework for Trading Pollution Credits

Following development of the planning level model and estimation of pollutant loads and control costs, a workshop will be conducted with representatives from the city, state, EPA, the University of Connecticut Cooperative Extension Service, neighboring jurisdictions, and local interest groups. The workshop will present the comparison between point and nonpoint source loads, and the cost-effectiveness of nitrogen controls for both sources. Within the context of these findings, recognizing the uncertainty in the load estimates, the workshop participants will be asked to develop and evaluate options for administering a point-nonpoint nitrogen trading program.

Critical Project Issues

There are a number of critical issues that the project will have to address:

1. What are the target levels of nitrogen load reductions for the Rippowam and Noroton River watersheds? The total maximum daily load for nitrogen discharges have not yet been developed for these watersheds. Without a target load it will be difficult to define the point at which trading becomes viable.
2. Are nitrogen trading ratios an appropriate mechanism for incorporating uncertainty in nonpoint source loads and BMP effectiveness? If so, what should the ratio be?
3. Who will receive nonpoint source nitrogen removal credits? In the study area watersheds there are no agricultural land uses, which in other point-nonpoint source studies were the recipients of trading credits.
4. What incentives are likely to work in a situation where the City of Stamford may be trading pollution credits with itself or with nearby municipalities (Darien, New Canaan)?
5. Can credits be used outside the Rippowam and Noroton watersheds, such as in other Long Island Sound watersheds?
6. How can the effectiveness of the overall program and of nonstructural BMPs, e.g., public education about fertilizer use, in particular, be measured?
7. What are the real administrative costs and institutional structures required to make trading work in an urbanized watershed?

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Point/Nonpoint Source Trading: A Discussion of Legal Requirements and Implementation Issues

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Environmental regulation is at an important crossroads. As environmental policies take shape in the cost-conscious 1990s, market-based incentive programs are emerging as an important component of the regulatory arsenal. Economists have long argued that this approach is more cost-effective than the "command-and-control" framework that has governed environmental regulation.

Most experimentation with incentive-based policy mechanisms has occurred in air quality control programs, yet water quality control may also benefit from effluent trading programs. One incentive-based approach for water quality control that has received attention recently is known as point/nonpoint source trading. In point/nonpoint source trading programs, point source dischargers provide funds for nonpoint source controls in lieu of advanced treatment requirements that would otherwise be necessary to achieve water quality objectives. Under current regulation, only point sources—typically municipal and industrial dischargers—face mandatory control requirements reflected in federally enforceable discharge limitations. Nonpoint sources of pollution, which contribute the largest share of pollutants to the Nation's waterways, are virtually unregulated. Communities are beginning to experiment with point/nonpoint source trading to reduce the costs of water quality control and to bring nonpoint source pollution into the regulatory reach of the Clean Water Act.

Given the rising costs of environmental protection, future environmental improvement efforts will need to incorporate cost-effective control options. This paper discusses legal requirements and implementation issues surrounding point/nonpoint source trading programs. More specifically, it examines the place of trading within the regulatory framework of the Clean Water Act, potential enforcement difficulties, and uncertainties that arise when shifting from point source to nonpoint source control.

Statutory Authority for Trading Programs

The Clean Water Act does not explicitly authorize trading or other market-based incentives for pollution control. Communities experimenting with point/nonpoint source trading must derive authority to do so from the general flexibility granted to states to establish water quality-based effluent limitations and to implement the goals of the Clean Water Act. From the broad language of key provisions of the Clean Water Act, however, one can infer the authority necessary to develop trading programs.

In general, trading programs appear to be permissible through section 302 (water quality related effluent limitations) and section 303 (water quality standards and implementation plans). Section 302 gives EPA authority to establish "effluent limitations (including alternative effluent control strategies)" for point sources that are more stringent than minimum technology-based controls, where such controls "can reasonably be expected to contribute to attainment or maintenance of water quality." A trading program appears to be an acceptable alternative control strategy within the

meaning of this provision. Section 303 allows EPA to approve effluent limitations at least as stringent as those required by technology-based controls in order to meet water quality standards. These stricter, water-quality based standards must be in place before trading programs are possible.

While provisions for water quality-based standards and water quality-related effluent limitations provide general authority to impose selectively stricter discharge limitations, two sections of the Clean Water Act relate most specifically to trading programs. First, section 303(d)(4), which calls for the creation of total maximum daily loads (TMDLs), includes provisions that resemble point/nonpoint source trading. A TMDL is the maximum amount of a pollutant that can enter a waterbody without violating its ambient water quality standard. Wasteload allocations established for point sources, and load allocations established for nonpoint sources and natural background together comprise the TMDL. Regulations developed to implement TMDLs permit consideration of economic factors, including the use of tradeoffs, within initial wasteload and load allocations. (40 CFR 130.2(i)).

Although TMDLs provide the foundation from which to develop a trading program, the tradeoffs allowed in an initial TMDL allocation differ fundamentally from incentive-based mechanisms in a point/nonpoint source trading program. In the TMDL process, regulators determine individual discharge levels. In a trading program, these initial load allocations form the starting point for developing an efficient control strategy. From this starting point, individual plant operators determine the most cost-effective control level within a maximum aggregate level of pollution. Trading occurs only when an initial allocation selected by regulators does not reflect the most cost-effective control level for an individual discharger.

Second, section 319, which promotes nonpoint source management on a watershed basis and provides federal grants for nonpoint source control projects, also contains statutory language that could accommodate trading programs. Section 319(b)(2)(B) requires that state management plans identify programs "including, as appropriate, nonregulatory or regulatory programs" to control nonpoint source pollution. In addition, EPA can give priority for grant awards to programs that implement "innovative methods or practices for controlling nonpoint sources of pollution, including regulatory programs where the Administrator deems appropriate." Trading programs, which bring nonpoint source pollution under regulatory control, are certainly an innovative method of basinwide water quality management. In fiscal year 1992, EPA set aside a portion of section 319(h) grant money specifically to assist states develop point/nonpoint source trading programs.

Legal Obligations of Trading Programs

Trading programs represent a significant departure from traditional regulatory control methods. Without explicit language authorizing nonregulatory control levels or trading program operating procedures, the functional criteria of the Clean Water Act provide the only yardstick by which to measure trading programs as appropriate means to achieve the Act's goals. Antibacksliding and antidegradation are interrelated provisions that form the heart of the Clean Water Act and provide important guidance to prevent trading programs from running astray of water quality objectives.

Antibacksliding

Antibacksliding provisions limit the extent to which point sources can increase discharges above previously permitted levels for a given pollutant. Antibacksliding provisions apply predominantly to technology-based limitations, but also restrain water quality-based effluent limitations from exceeding TMDL levels. Section 303(d)(4)(A) specifically provides that effluent limitations based on TMDLs or other waste load allocation may be revised only if "the cumulative effect of all such revised effluent limitations based on such total maximum daily load or waste load allocation will assure attainment of such water quality standard. . . ." However, because antibacksliding is only relevant for pollutants included in previous permits, it may not affect trading programs involving nutrients because many dischargers do not have existing nutrient limits in their permits.

Even if antibacksliding does not directly affect nutrient trading programs, the

language in section 303(d)(4)(A) governing revised effluent limitations is essential to the implied authority for trading programs. It is the only provision of the Clean Water Act that provides guidance for modification of effluent limitations established under a TMDL. While it does not explicitly authorize trading, it establishes bounds within which trading programs must operate.

Antidegradation

The Clean Water Act antidegradation provision (40 CFR 131.12), which is designed to prevent deterioration of water quality in certain waterbodies, differs significantly from antibacksliding. Whereas antibacksliding applies to individual discharge levels, antidegradation applies to ambient water quality. As such, antidegradation encompasses nonpoint sources as well as point sources. When applied to trading programs, the antidegradation provision can be used to prevent a reduction in water quality. Where water quality equals or exceeds levels necessary to protect designated uses, a state may revise an effluent limitation based on a TMDL or other wasteload allocation only if such revision is "subject to and consistent with the antidegradation policy established under this section" (§304(d)(4)(B)). Thus, when combined with the antibacksliding provisions described above, antidegradation provides important checks on a trading program.

Implementation Issues

Finding legal authority for point/nonpoint source trading programs is only one part of successful program implementation. For point/nonpoint source trading to offer an effective alternative to traditional regulatory approaches, it must overcome numerous uncertainties surrounding nonpoint source control as well as potential monitoring and enforcement programs. A trading program that resolves only the cost-efficiency issue will generate new problems in the process. The following section highlights major implementation issues.

Nonpoint Source Loading and Control Uncertainty

Nonpoint source loading and control choices are burdened with uncertainty. Uncertainty affects both the timing and concentration of nonpoint source pollutant loads and the types of control methods (known as best management practices (BMPs)) used to reduce nonpoint source pollution. These critical characteristics of nonpoint source pollution must be evaluated against the relative certainties of point source loading and control options because a trading program relies on the ability of nonpoint source control devices to assume control responsibility that would otherwise fall on point sources. Thus, trading programs present a tradeoff between control cost-savings and reliable water quality improvements. Most studies that evaluate the cost-effectiveness of nonpoint source controls overlook their inherent uncertainties.

Several problematic shortcomings of BMPs affect a shift of control responsibility from point source to nonpoint source controls. First, nonpoint source controls may not achieve expected annual load reductions. Second, BMPs are not always fully or properly implemented, due to lack of institutional commitment or inadequate resources. Nonpoint source controls are successful alternatives to point source control only if they are applied diligently on the ground. For these reasons, one cannot accurately predict the extent to which trading programs will alleviate water pollution problems.

Trading Ratio

Much of the success of a trading program, as measured by improved water quality, rests with the difficult decision of choosing an appropriate trading ratio. A trading ratio acts as the exchange rate that equates the environmental impact of point and nonpoint source loadings. It is the amount of nonpoint source control that a point source discharger must undertake to generate a unit of credit at the point source. Under a 2:1 trading ratio, for example, a point source would be required to control two units of nonpoint source pollution for each unit of credit received. The trading ratio is generally set higher than one to compensate for perceived uncertainty in nonpoint source control. However, if set too high, the economic incentives to trade will be reduced from the point of view of the point source, and trading may not occur. If set too low, possible improvements in water quality may be sacrificed, especially if the point source relies on trading to meet

substantial levels of its discharge reduction obligation.

The decision rule used to select a trading ratio is simple in theory only. A trading ratio must incorporate both the uncertainty of nonpoint source control and the different environmental impacts caused by point and nonpoint sources of pollution so that decisions made on the basis of marginal cost analysis will result in comparable levels of water quality improvement. The ultimate danger of choosing an incorrect trading ratio is that environmental protection objectives will be sacrificed.

Monitoring

Substantial monitoring and modeling information is necessary to shift successfully from a command-and-control approach to a trading program and to determine whether nonpoint source control will adequately protect water quality. The monitoring requirements necessary to track trades and report the effectiveness of BMPs may present significant barriers to trading. For the most part, the Clean Water Act shifts the cost of monitoring compliance to point source dischargers. Section 308 imposes substantial monitoring and reporting requirements on all NPDES dischargers. Every point source must maintain records; install, use, and maintain monitoring equipment; and sample effluents on a regular basis. Presumably, similar monitoring requirements would need to be in place for nonpoint source controls used to offset a point source's reduction obligations.

Monitoring probably will be more costly and time-consuming for nonpoint source control than for point source control, where a system has been in place for two decades. If nonpoint source controls were used to offset point source control responsibility, monitoring and enforcement responsibilities would extend to multiple sites. Instead of compiling discharge monitoring reports from information collected on-site, a point source discharger would need to travel to all nonpoint source control sites to obtain necessary information. These costs would likely rise as the number of trades increased. The volume of information required to implement such a program without undue risk of sacrificing water quality may prove an insurmountable burden. In fact, the amount of information required to gauge a pollutant's effects on water quality and to monitor actual pollutant levels, together with the difficulty of developing sufficient enforcement mechanisms, may hinder the success of trading programs.

Enforcement

The primary concern with trading programs is one of responsibility: if a nonpoint source control project fails, who is ultimately responsible for correcting the situation, and who can be sued if the situation remains uncorrected? Current Clean Water Act enforcement provisions, although not infallible, are binding only on point sources that must adhere to obligations enumerated in NPDES permits. Trading programs, however, are premised on market-based discharge limits, where a point source can offset additional pollution loads by providing a predetermined degree of nonpoint source control. By relying on market forces to set optimal control levels, a trading program potentially can escape from enforceable discharge levels. This is clearly unacceptable.

For a trading program to be effective, any alternative control responsibility must be specifically incorporated into a point source discharger's NPDES permit so that the point source remains accountable for its specified level of control. Permit violations must also be enforced. Permit systems provide administrative means to track pollutant loading and form the basis for enforcement mechanisms. Yet bringing a trading program under the permit umbrella may pose increased administrative burdens. EPA also retains enforcement power when a point source's obligation for nonpoint source control is written into its NPDES permit. A trading program must be established such that cost-saving, not enforcement evasion, is the motivation driving a point source discharger to seek alternative control strategies.

Provided that alternative nonpoint source control obligations obtained though trading are clearly established in NPDES permits, existing Clean Water Act enforcement provisions should extend to point source obligations incurred in a trading program. As point sources shifted more and more of their control obligation to nonpoint sources, they might jeopardize compliance with permit requirements. The point source discharger would be subject to enforcement measures for noncompliance, but its control obligation would be dependent upon the ability of nonpoint source controls to bring about required pollutant reduction. Because

it is difficult to prove a direct link between a specific nonpoint source and water quality levels, the causal link for establishing noncompliance would have to be tied to permit obligations outlining nonpoint source control responsibility. Incorporating nonpoint source control responsibility into permits (i.e., requiring that a farmer participating in nonpoint source control projects associated with a trading program assume responsibility for maintaining BMPs) may reduce farmers' incentives to participate if they would not otherwise face regulatory control. If violations could be enforced only against point sources, the potential fines for permit violations together with long-term monitoring obligations may outweigh potential control cost savings.

EPA also has a right of entry onto any premises where an effluent source is located (40 CFR 122.41(i)). In a trading program, this authority would need to extend to locations of nonpoint source controls used in place of point source control obligations in order to ensure compliance. As with monitoring obligations, enforcement costs would likely increase if enforcement officials were required to make visits to multiple nonpoint source control sites. However, EPA's broad authority to conduct warrantless searches of point source dischargers may conflict with privacy issues and protections against unreasonable searches if transferred to nonpoint source sites.

Potential Statutory and Regulatory Revisions

Statutory and regulatory revisions could help overcome perceived hurdles associated with implementing a program only implicitly authorized by statute and regulations. Potential statutory changes include bringing point/nonpoint source trading programs within the goals of the Clean Water Act, explicit endorsement of trading in established Clean Water Act programs, and amending section 319 to promote trading as a valid tool for nonpoint source management plans. Regulatory revisions include issuing specific guidance to authorize trading as a preferred or desirable method for controlling water quality, and requiring that communities assess trading opportunities in water quality management strategies. Each alternative will affect the degree to which trading programs proliferate and the additional burdens and unresolved issues that accompany program implementation. To date, EPA has not yet developed a formal trading policy, but it is actively exploring point/nonpoint source trading as a viable water quality management tool.

Conclusion

Point/nonpoint source trading may hold promise as an innovative technique in water quality control. However, it is not a panacea for solving remaining water quality problems. If trading programs are to evolve beyond the conceptual stage, communities must focus carefully on the specifics of program and policy design. Cost-effectiveness is only one issue. A shift away from traditional command-and-control regulation presents several practical implementation issues that must be analyzed as closely as potential cost-savings. A trading program that does not adequately resolve monitoring, enforcement, and uncertainty issues may be plagued with loopholes that offset anticipated benefits, and leave instead a legacy of reduced water quality.

NOTE: This paper is based on the author's article, Point/Nonpoint Source Trading: Looking Beyond Potential Cost Savings, 23 *Environmental Law* 43-106, which presents a more detailed analysis of implementation issues surrounding trading programs.

Farmstead Assessments—A Voluntary Approach for Identifying and Implementing Farmstead Practices to Prevent Pollution

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Farmsteads include farm buildings and the land around them. These sites are increasingly being recognized as potential sources of surface and ground-water contamination in rural areas. The concentration of potential contaminants and intensity of activities around farmsteads can generate significant amounts of nitrate, toxins, and microorganisms. Wells on the farmstead and local ground water are often vulnerable to contamination from these contaminants.

The Farmstead Assessment (Farm*A*Syst) Program has been designed to aid farmers and rural residents in identifying well water and ground-water pollution risks and in developing voluntary action plans to reduce identified high risks (Jones and Jackson, 1990). It was developed in response to farmers' and rural residents' concerns about protecting well water quality. A recent Gallup survey (Sandoz, 1993) shows that "farmers are more concerned about farm environmental issues today than they were five years ago." The Farm*A*Syst Program is assisting concerned farmers in addressing water quality-related concerns.

This paper characterizes the nature of pollution risks around farmsteads; provides a brief history of factors which influenced the development and design of the farmstead assessment system and its national expansion; and presents information on Farm*A*Syst Program development procedures, implementation strategies, and pilot program implementation results.

Farmstead Pollution Risks

To characterize the nature of pollution risks associated with farmstead activities a hypothetical farmstead has been analyzed. This farmstead is located on a farm that has 100 animal units and 200 acres of cropland in a corn/alfalfa rotation. Table 1 estimates the amount of potential pollutants that may be handled at this site in a typical year.

Pollution risks for toxins, nitrate, and microorganisms from these sources can be evaluated through use of the Farmstead Assessment System. Microorganisms are the most frequent contaminant in private wells and the contaminant that is most likely to cause acute illness. Microorganism contamination can come from septic systems or other on-site waste disposal systems, livestock holding areas, livestock waste storage areas and facilities, and milkhouse waste disposal systems.

Table 1. Estimate of potential pollutants at a typical 100-animal-unit dairy farmstead

Potential Pollution Source	Estimated Amount Per Year
Livestock wastes	17,000 pounds of nitrogen
Milking center wastes	150 pounds of nitrogen
Septic system	50 pounds of nitrogen
Fertilizer	15,000 pounds of nitrogen
Silage	30,000 pounds of nitrogen
Pesticides	700 pounds active ingredients (varies extensively)
Petroleum products	3,300 gallons
Household hazardous wastes	10 pounds
Farm and shop hazardous wastes	20 pounds (varies extensively)

Data from several projects support the need for this type of program. Data from an American Farm Bureau Report (October 1992), based on data from approximately 35, 000 wells, documented that:

- Shallower and older wells are more likely to be contaminated than deeper and newer wells; and springs, driven wells, and dug wells are more likely to be contaminated than drilled wells.
- Where contamination is present, nitrate concentrations often exhibit considerable month to month variability, especially when the wells are tapping shallow aquifers and/or suffer from faulty construction.
- Soil type, proximity to cropland or feedlots, and mixing chemicals near the well are all important factors in whether or not contamination is present.

All of these factors are evaluated when the Farmstead Assessment System is used to evaluate pollution risks at a specific site.

A Wisconsin Water Resources Management Program project report (August 1989), *Integrating the Groundwater Component Into The Priority Watershed Program,* used a modified version of farmstead assessment materials to evaluate ground-water pollution risks. Table 2 shows results of their farmstead pollution potential evaluations. The scores in the table reflect the frequency of potential pollution factors for the whole watershed. They do not reflect conditions on a particular farm. This study notes that while researchers have paid considerable attention to the surface water impacts of these wastes, they have paid little attention to ground-water impacts.

Table 2. Pollution potential ranking of farm management

Activity	Score (x100)
Petroleum storage	83
Septic systems	63
Pesticide handling	55
Nitrogen fertilizer and manure application	50
Milkhouse waste disposal	50
Hazardous waste disposal	40
Livestock yards	39
Livestock manure storage	38
Well condition	38
Silage management	25

The most fundamental recommendation of this report is that in priority watershed projects, surface water, ground water, soil resources, and human resources must be considered as an integrated system.

A study in Kansas showed a direct correlation between the level of nitrate contamination of wells and the proximity of the well to the farmstead. The Big Springs Groundwater Project in Iowa has done extensive well water testing and work in identifying nutrient management needs for cropland. Their education and demonstration activities resulted in reducing total nutrient applications. However, recently reported data (Seigley and Hallberg, 1993) indicate that nitrate levels in farm wells located in the project have increased rather than decreased. The report indicates this increase is related to the rainfall cycle of recent years. The role of farmstead, and rural non-farm nitrate sources have not been evaluated as potential influencing factors.

History of Farm*A*Syst Development

The Farmstead Assessment System was developed in response to farmers' and rural non-farm citizens' concerns about protecting their drinking water wells. Participants in drinking water education programs consistently inquired about how to identify potential sources of contamination for their well and what they could do to reduce or prevent pollution. These inquiries, in combination with recognition that wellhead protection strategies usually start by evaluating a well's design and identifying potential pollution sources closest to the well, provided the motivation for evaluating pollution risks associated with farmstead activities and structures. When designing the program, two significant questions were addressed—how to organize information on the complex array of farmstead management practices and structures into a functional format and how to determine farmer and rural residents' willingness to participate in voluntary on-site pollution risks assessments.

The home and farm energy audit was identified as a model that could be used for designing the program. Both programs assess technical and management factors related to causes of the problem; identify specific products, materials, or management practices to reduce the problem; and develop practice implementation support mechanisms that assist and encourage participants to take voluntary actions to reduce the problem. To determine the willingness of farmers to participate, approximately 250 farmers who participated in a Clark County, Wisconsin, drinking water education

program were surveyed (Jackson, 1987) to determine their willingness to participate in an anonymous, voluntary, on-site pollution risk assessment. Forty-four percent of the respondents indicated they would participate. This level of interest supported efforts to obtain funding to develop what became the Farm*A*Syst Program. Funding to develop the program for Wisconsin and Minnesota was obtained from the Extension Service, U.S. Environmental Protection Agency (EPA) Region V, and the North Central Rural Development Center. The program was developed as a cooperative effort between EPA Region V, Wisconsin Extension Service, Minnesota Extension Service, and the Soil Conservation Service (SCS). After completion of the prototype materials a proposal to assist other North Central Region States in modifying the materials for their use was developed. The U.S. Department of Agriculture (USDA) and EPA expanded that proposal into a coordinated national expansion effort. This national expansion is being jointly funded and staffed by the Extension Service, SCS, and EPA. To date, nearly 45 states have indicated their intent to develop and implement Farm*A*Syst type programs; 15 states have completed or nearly completed modification of the materials (at least 6 states are in pilot implementation efforts); approximately 15 states are in the process of modifying materials; and 15 states intend to initiate the modification process during calendar year 1993.

Developing and Implementing State Farm*A*Syst Programs

Development and implementation of an effective Farm*A*Syst program requires building partnerships between numerous agencies, farm organizations, conservation organizations, and the businesses and industries that provide products and services necessary to prevent pollution. Policies and programs related to farmstead practices and structures that influence pollution risks are part of the responsibilities of USDA agencies and EPA programs at the national level. However, to be effective, programs must be tailored to accurately reflect the policies and programs of state and local agencies and organizations that work directly with farmers and rural residents. This requires development of cooperative efforts to organize water quality protection policies and programs into one system that aids farmers in:

- Understanding and identifying pollution risks associated with their farm.
- Identifying actions that will reduce pollution risks.
- Understanding how existing programs and policies can help prevent pollution.
- Obtaining technical, financial, and educational assistance to prevent pollution.
- Taking voluntary actions to reduce pollution risks.

Pilot Program Implementation Results

Pilot Farm*A*Syst implementation results indicate that the program is effective in assisting rural residents and farmers in identifying pollution risks associated with their activities and structures. More importantly, pilot results indicate that participants are using knowledge gained through this program to voluntarily modify practices and structures in ways that reduce pollution risk. Table 3 (unpublished survey, January 1993) show results from a Waupaca County, Wisconsin pilot implementation program, conducted in cooperation with local agri-business.

Significant changes in high-pollution-risk practices occurred without a formal practice and implementation support

Table 3. Waupaca County pilot agri-business Farm*A*Syst delivery results 1991-92

Worksheet	High Risk Practices Identified?[a]	Changes Planned?[b]	Changes Made?[b]
#1 Wells	25%	60%	20%
#2 Pesticides	35%	100%	85%
#3 Fertilizers	10%	100%	0%
#4 Petroleum	75%	100%	33%
#5 Hazardous Waste	15%	0%	100%
#6 Household Wastewater	25%	80%	40%
#7 Livestock Waste	20%	75%	50%
#8 Livestock Yards	20%	75%	50%
#9 Silage	10%	50%	100%
#10 Milking Center Wastewater	10%	100%	50%

[a] N = 20.
[b] Percentage of those farms with high-risk practice identified. Survey information was collected 3-6 months after assessments were conducted.

mechanism. However, local information on suppliers of the products and services that reduce pollution risk was developed into a local resource directory to assist landowners with implementing action recommendations. When asked to rate the usefulness of the program, 65 percent of the participants rated it as very useful and 35 percent rated it as useful.

Results from a follow-up telephone survey with 15 consultants and agri-business staff who worked with 87 farmers in 3 county pilot delivery projects documented reactions to use of the Farmstead Assessment System materials; suggestions for improvements; and perceptions of farmers reactions to the program. All 15 staff felt the materials were well written and easy to work through. Suggestion for changes were minor. Fourteen of the staff felt the program was positively received by farmers and one staff person felt farmers "were a little disappointed, (and) expected more information."

Waupaca County (Blonde, Wilson, September 1992) also integrated Farm*A*Syst into a drinking water education project. A pre- and post-program survey indicates that participation in the drinking water education program significantly increased participants knowledge of ground water and that participation in both the drinking water education program and the Farm*A*Syst program resulted in increased voluntary adoption of practices to reduce ground water contamination risks.

Three groups were surveyed—nonparticipants, those who received well test results by mail, and those who participated in the drinking water education and Farm*A*Syst workshop. Table 4 shows the difference in practice changes and changes planned between these groups. Group 1 did not participate in well test or workshop. Group 2's well test results and information were received by mail. Group 3's well test results were provided through an educational workshop.

In the Minnesota Anoka Sand Plains USDA Demonstration Project the goal is to complete 100 assessments. To date, 56 assessments have been completed. Some very preliminary results are presented in Table 5. Forty-four percent of the participants had at least one worksheet with a total ranking score in either the moderate-to-high risk or high risk categories (Jackson and Anderson, 1993).

Table 5. Percent moderate to high risk ranking for completed assessments

Topic	% Participants Completed Worksheets
Wells	0
Pesticides	18
Fertilizers	14
Petroleum	48
Hazardous Waste	16
Household Wastewater	20
Livestock Waste	16
Livestock Yard	30
Silage	21
Milking Center	11

These pilot implementation results indicate the Farm*A*Syst program is being well received; is effective in increasing knowledge of factors that influence pollution risks; and, most importantly, is resulting in voluntary actions by participants to reduce risks.

Table 4. Practice changes resulting from drinking water education programs

Change in Use of Pollution Prevention Practices	Group 1 N=37	Group 2 N=14	Group 3 N=37
Practices implemented	16%	21%	46%
Practices planned	14%	36%	51%

Group 1 = Did not participate in well test or workshop.
Group 2 = Well test results and information received by mail.
Group 3 = Well test results provided through an educational workshop.
N = Number responding

Implementation Approaches

Interagency cooperation in the development of well-designed fact sheets and worksheets provides a sound foundation for identifying, discussing, and developing cooperative approaches for making this program available to farmers. Five primary delivery methods that have been used are:

1. One-on-one assistance on the farm.
2. Group assessments with educational and technical assistance.

3. Combination of group orientation with follow-up one-on-one assistance.
4. Incorporation into other education programs, i.e., drinking water education, ground-water education, pesticide application training, farm management education, etc.
5. Self assessment (mailed/media).

The objective is to get the program used on as many farms as possible and to encourage voluntary actions to reduce or prevent pollution. Thus, there may be benefits to using multiple delivery mechanisms involving several agencies and private sector organizations.

Implementation Support Systems

Farm*A*Syst program implementation efforts and the extent of voluntary pollution prevention practice implementation by participants can be strengthened through development of state and local support systems. Many of the needed components of these systems are already in place in existing agencies, organizations, and the private sector. Successful involvement of those who are responsible for these support systems in material and program development will help to build the foundation for a coordinated implementation effort that is based upon the existing capacity of involved parties.

Two types of implementation support must be considered for delivering Farm*A*Syst programs:

- Systems that support conducting assessments and the development of action recommendations to reduce pollution risks.
- Systems that support, encourage, and assist farmers in voluntarily carrying out recommendations that reduce pollution risks.

Once the delivery mechanisms are identified, support for staff training and technical referral mechanisms must be developed. At least three components of staff training must be addressed:

1. Orientation to water quality and its relationship to land use practices, identification of farmstead pollution sources, and how to use the assessment support materials.
2. Supervised hands-on experience in conducting assessments.
3. Development of action recommendations to reduce identified risks, including information on existing policies and programs which influence recommendations and/or can assist with practice implementation.

The development of technical referral networks is important because delivery staff will not be experts on all of the potential pollution sources they evaluate and the Farm*A*Syst materials do not completely cover all of the factors that influence pollution risks. Technical referral networks will increase the accuracy of the action plan recommendations and allow for appropriate involvement of agencies that have authority or responsibility for specific practices.

The Congressional Office of Technology Assessment Report (November 1990), *Beneath the Bottom Line*, recognizes that:

> Adoption of management practices and systems to reduce ground-water contamination by agri-chemicals ultimately depends on decisions made by individual farmers. Information delivery and technical assistance programs to reduce groundwater contamination will be more effective if they are based on an understanding of factors influencing producers' decisions and address producers' constraints to technology adoption.

It further states:

> The Farmstead Assessment Program under development in several States is designed to identify potential farmstead sources of groundwater contamination, and to educated farmers about management practices to prevent groundwater contamination. Further effort could promote development and adoption of such practices, and also could increase awareness of the variety of potential farmstead sources of groundwater contamination.

Their findings support the belief that developing pollution prevention, practice, implementation, support systems will increase participants voluntary implementation of recommended practices. Active involvement of local industries in promoting pollution prevention efforts should reinforce recommendations of Farm*A*Syst volun-

tary action plans. Active marketing of the products and services needed to implement the recommendation should increase the program's effectiveness.

Conclusions and Recommendations

Experiences in developing and implementing Farm*A*Syst type programs have resulted in the following conclusions:

1. Farmers and rural residents are concerned about well water and ground-water quality and are willing to take voluntary actions to prevent contamination.
2. It is unrealistic to expect individual farmers and homeowners to independently understand all the factors that influence pollution risk.
3. Farm*A*Syst type programs can effectively assist individuals in identifying pollution risk and in understanding changes that can reduce risks.
4. Coordinated involvement of agencies with authority and responsibility for water quality protection and the private sector that provides products and services that help prevent pollution risk is very important.
5. Pollution prevention is much more cost-effective than cleanup, but, to be effective, more support is needed to develop effective implementation of programs.
6. When developing Farm*A*Syst programs, staff with coalition building skills as well as staff with technical skills must be involved.
7. This program should be coordinated with integrated crop management and nutrient and pest management programs to develop a whole farm ground-water protection plan.

These conclusions support the following recommendations:

1. Farm*A*Syst type programs for water quality pollution prevention should be consciously integrated into future water quality protection efforts.
2. Mechanisms to provide stable funding for staff who can provide leadership in program development and implementation should be developed.
3. Training programs for staff who will be involved in implementation of voluntary pollution prevention risk assessments should be developed.
4. Support materials to assist implementation staff in identifying action recommendations needed to reduce pollution risks should be developed.
5. Mechanisms to expand this program into a whole farm water quality protection program should be developed.

Summary

Farmstead management practices and structures can pose significant contamination risks to ground water and well water. Farmers and rural non-farm citizens who are concerned about protecting the quality of their well water often do not understand the relationship of their activities to these risks. Pilot Farm*A*Syst implementation results indicate that this program is effective in assisting rural residents and farmers in identifying pollution risks associated with their activities and structures. More importantly, pilot results indicate participants are using knowledge gained through this program to voluntarily modify practices and structures to reduce pollution risks. Findings of the 1993 Sandoz National Agricultural Poll indicate:

> Overwhelmingly, farmers believe the key to reducing public concerns about farm-related environmental issues is education. Most feel they share responsibility for that education with government, teachers, manufacturers, and others.

Designing and implementing voluntary Farm*A*Syst pollution prevention programs for farms and rural residents can be an effective way to direct these concerns and beliefs into action.

The Farm*A*Syst program can reduce pollution problems through developing cost-effective cooperative relationship between responsible agencies and the private sector. Forging these partnerships requires an on-going commitment from agencies that have authority and responsibility related to potential pollution sources. It also requires active involvement of education institutions and the industries and organizations which provide products and services which are

necessary for reducing and/or preventing pollution. Development of this coordinated effort can reduce duplication of services by different agencies and improve the cost-effectiveness of water quality protection and management efforts.

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Application of Watershed Index of Pollution Potential to Aerial Inventory of Land Uses and Nonpoint Pollution Sources

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The Tennessee Valley Authority (TVA) utilizes low-altitude color infrared (CIR) photography to identify and characterize land uses and nonpoint sources (NPS) of pollution as part of the agency's water resources management activities (Perchalski and Higgins, 1988). Low-altitude CIR photography (nominal scale of 1:24000) allows for detailed classification of land use and land cover, types of NPS sites, ephemeral and intermittent drainage patterns, and streambank vegetative cover. The NPS inventories provide a map and tabular summary of NPS activities within watershed project areas. More than 22,000 square kilometers (8700 square miles) of the Tennessee River drainage have been surveyed by this technique. An index of pollution potential by NPS has been developed to enhance the assessment value of aerial survey results (Sagona and Phillips, 1993). This index helps TVA to plan and focus monitoring, modeling, and treatment efforts.

Index Overview

The watershed index of pollution potential (WIPP) is an index that rates NPS activities within a watershed. The index uses photo-interpreted features as surrogate indicators of potential inputs for general classes of pollutants such as nutrients, pathogens, sediment, and toxics. The NPS activities within a watershed are evaluated for two distinctive scenarios: those activities that may be significant during *runoff* events and those activities that may be significant during *non-runoff* conditions. Each scenario has a set of metrics used to group the surveyed features. Scoring criteria are established for each feature based on the occurrence of the feature in the watershed relative to the occurrence of the feature for the entire project area.

Rationale for WIPP

Since it is not feasible to treat all sources of NPS, a process is needed to target the more significant sources impairing the quality of water resources. A first step involves identifying the waterbody to be protected and predominant pollutant sources affecting it (Maas et al., 1987). The point of reference is a term used in WIPP to convey the location and pollutant(s) of interest. The location in a watershed where the effects of pollutant sources or treatment will be measured determines the appropriate land use features to be evaluated. For example, different land use features are evaluated if the point of reference is a reservoir's water quality rather than the inherent quality of streams feeding the reservoir. While the

former point of reference is influenced by both runoff and non-runoff events, the watershed evaluation would likely emphasize NPS features that contribute pollutants to the mass loading to the reservoir, i.e., runoff scenario NPS features. The focus for stream quality evaluations would emphasize daily (ambient) NPS features and not just runoff conditions. WIPP provides a mechanism to differentiate and rate NPS features for the two scenarios. WIPP can be generalized to evaluate NPS for broad stream quality objectives or be made specific to evaluate NPS for more focused objectives.

WIPP takes a rule-base model approach to evaluate pollution potential of NPS. In a rule-base model, a set of rules are established to predict or describe changes in the ecology of a system (Starfield et al., 1990). WIPP is in an initial phase of a rule-based approach. Descriptive linkages have been established between source, type of pollution, and general effects on stream quality. However, "rules" that predict changes in the stream system as a result of specific NPS control actions still need to be developed and incorporated. An advantage of a rule-base model approach is that inputs and evaluations can be changed to match available data and current understandings of relationships.

Biological community response is the link used to describe the effects on stream quality. Generally, stream biota provide clues into environmental inputs and community responses (Adams, 1990). The index of biotic integrity (IBI) is the stream parameter used to characterize the aquatic community (Karr et al., 1986). The IBI consists of 12 ecological characteristics that describe species richness, trophic composition, and fish abundance and condition (Karr, 1987). Information inferred from the IBI metrics is used to describe community shifts. These shifts are associated with environmental influences such as general pollutant classes and/or watershed characteristics. Sources of these influences are obtained from the aerial survey data. Associations are established without necessarily requiring or acquiring extensive water quality data before acting on solutions: stream biota describe stream impacts; stream impacts indicate limiting NPS features; NPS features guide selection of appropriate NPS controls.

Metrics Description

The "inputs" for WIPP are simply the photo-interpreted features and other physical watershed characteristics used as indicators for the general classes of pollutants and stream features that can influence stream quality. Interpreted features are grouped by scenario and by metric. Table 1 illustrates the arrangement of scenarios, metrics, and features used to evaluate NPS potential for a typical watershed project. The scenarios are intended to differentiate the evaluation of the watershed into those features that are related to ambient stream conditions (non-runoff) and those that may be significant to mass loadings to the system (runoff). The metrics are the predominant parameters of interest to be evaluated for each scenario. Metrics can be added or deleted to reflect project purposes. A metric may appear in each scenario; however, different aspects are being considered. For example, the sediment metric for the non-runoff condition evaluates NPS features that contribute sediment and turbidity on a daily basis to ambient stream conditions. These relatively low "mass" inputs can be significant to stream biology during stressful times of the year (e.g., low streamflows, high water temperatures). The sediment metric in the runoff scenario evaluates the potential for relative mass loadings of sediment to the system. The streambank condition metric is used as a relative indication of riparian condition. Riparian integrity is recognized as a significant feature contributing to overall stream quality (Lowrance et al., 1985; Phillips, 1989; Schlosser and Karr, 1981). This metric indicates the potential degree of streambank disturbances that may effect stream biota.

Several features appear in multiple metrics and under both scenarios. The reason is that a single landscape feature may affect multiple stream parameters. For example, livestock access to streams represent a source of nutrients and pathogens, sediment and turbidity, and may indicate riparian habitat damage or loss. This NPS feature has potential to introduce pollutants under both scenario conditions. However, it may be more significant to overall stream health during non-runoff conditions and is just one of many pollutant sources during runoff conditions. Also, there are varying numbers of features used in each

Table 1. General description of WIPP metrics

Metric		Feature[a]
Scenario: Non-runoff		
I. Nutrients, pathogens	1.	number of livestock operations adjacent to stream
	2.	number of stream locations with livestock access
	3.	areal extent of feedlots and holding areas
	4.	length of stream with potential access by livestock
II. Sediment, turbidity	5.	number of stream locations with livestock access
	6.	areal extent of feedlots and holding areas
	7.	length of stream with potential access by livestock
	8.	length of stream disturbed by channelization or eroding banks
III. Streambank condition[b]	9.	length of stream with little or no woody canopy cover
	10.	length of channelized streams
	11.	length of stream with potential access by livestock
	12.	length of stream with livestock access
	13.	length of stream with no buffer
Scenario: Runoff		
IV. Nutrients, pathogens	14.	number of livestock operations
	15.	number of stream locations of livestock access
	16.	areal extent of pasture in poor or fair condition
	17.	areal extent of feedlots and holding areas
	18.	length of stream adjacent to pasture
V. Sediment	19.	length of unpaved roads
	20.	length of eroding roadbanks
	21.	length of eroding streambanks
	22.	soil loss potential (annual total)
	23.	areal extent of pastureland
	24.	areal extent of cropland
	25.	areal extent of barren or denuded land
	26.	length of stream with access and potential access by livestock
VI. Transport	27.	ratio of a given storm runoff flow to base flow
	28.	ratio of annual high flow to annual low flow
	29.	time of concentration based on physical characteristics
	30.	time base for 10-yr storm event runoff
	31.	SCS runoff curve number for watershed
	32.	transport potential of stream at watershed outlet
	33.	length of channelized streams

[a]Based on results of low-altitude color infrared aerial survey of land uses and nonpoint pollution sources. Transport function metric based on physical watershed characteristics from topographic maps and published stream flow data. Features list can be adapted to other available land use data bases.
[b]This metric is used to indicate relative condition of riparian habitat.

metric. This recognizes that a pollutant class may have multiple sources. For example, there are more features for sediment and turbidity under the runoff scenario than there are for the non-runoff scenario. This simply reflects the fact that there are more sources of sediment during runoff events than there are under non-runoff conditions. For example, eroding roadbanks do not contribute sediment to the system on a daily basis, but can contribute significant amounts of sediment during runoff events. This land use feature, if inventoried, is included as a sediment source for the runoff scenario. The number and type of features included in WIPP reflect the level of land use classifications available. Thus the metrics can be adapted for satellite, high-altitude, or low-altitude data sources. This paper presents the concept of WIPP based on low-altitude CIR survey results.

Metrics Scoring Criteria

WIPP scoring is accomplished at three levels: feature scoring, metric scoring, and scenario scoring. Feature scores are the rudimentary elements in the WIPP scoring scheme. Metric and scenario scores are a function of the feature scores. Feature scores are based on actual watershed features and scored as 1, 3, or 5 to indicate high, medium, or low NPS pollution potential, respectively. Each feature is evaluated and scored by summing or counting inventory values. A mean and standard deviation are calculated for the specific feature data set. A medium range for the feature is established using the feature mean plus or minus an adjusted standard deviation. The standard deviation is adjusted by multiplying by the following coefficient:

(1-((absolute value of (mode-mean))/ standard deviation)) (1)

Metric scores consist of a summation of feature scores multiplied by 4 and divided by the number of features used in the metric class. This function sets a maximum possible score of 20 and a minimum score of 4 for each metric. It also ensures that when calculating the scenario score, each metric is represented equally regardless of the number of features present in the metric.

Scenario scores are a summation of the metrics for the scenario. The maximum score is 60 and the minimum score is 12. The actual WIPP score is an average of the two scenario scores. The higher the WIPP score, the lower the potential for NPS pollution. The lower the WIPP score, the higher the potential for NPS impacts on stream quality. The scoring scheme for WIPP is strongly influenced by that developed by Karr for IBI (Karr et al., 1986). This is done because IBI figures prominently in the connection between land use features and stream quality (Sagona, 1992). It is believed that comparable levels of resolution exist between the two indices to describe community response as indicated by IBI metrics and associated environmental influences indicated by WIPP features.

WIPP Application

The WIPP was applied to aerial inventory results for the Middle Fork Holston River drainage in southwest Virginia. The project area is about 620 square kilometers (240 square miles). The Middle Fork Holston River drainage has been identified as a watershed with significant stream impacts attributed to agricultural NPS (Cox, 1986). Table 2 summarizes the metrics and scores used to calculate WIPP for the project. Several of the watersheds have been surveyed using IBI as an indicator of stream quality (Saylor et al. 1988; Saylor, 1992). Figure 1 presents summary scores for both WIPP and IBI. All WIPP scores are relative to the project area. Thus Nicks Creek's (NC) WIPP score of 60 means that this watershed has the least potential for NPS pollution when compared to other watersheds in the project area. The relationship of WIPP to stream quality is established by stream monitoring, for this project, by the IBI. In general, WIPP tended to be a more conservative estimate for stream impacts than were actually measured by IBI. An apparently large disparity between WIPP and IBI results (i.e., more than 10 points) was observed for Laurel Springs Creek (LSC), Hall Creek (HLC), and upper Middle Fork Holston River (UMF). Follow-up investigation into the Laurel Springs drainage revealed historical fish kills attributed to a defunct dairy processing plant. The stream has a mill dam near its mouth which precludes recruitment from the main river. Additionally, historic and current recruitment from tributaries to Laurel Springs Creek has been limited due to extensive livestock access to feeder streams. The disparity observed for Hall Creek and upper Middle Fork Holston River may be a statistical artifact. WIPP evaluates pollution potential based on actual occurrences of NPS features in watersheds. Larger watersheds, if extensively developed will have higher frequencies for NPS features, and thus higher potentials for stream impacts. Actual stream quality data for Hall and upper Middle Fork Holston suggest some NPS impacts but not to the extent predicted by WIPP. Hall Creek has numerous springs that may be increasing the capacity of the stream to assimilate the watershed's NPS inputs. This in combination with a more "uniform" spatial distribution of NPS within the watershed may be sufficient to prevent the stream from being severely impacted. The IBI score for upper Middle Fork Holston indicate that this stream is being stressed. This suggests that NPS may be contributing to the decline in stream quality. For reference, there are no major point source discharges in either watershed.

Table 2. Summary of Watershed Index of Pollution Potential scores for Middle Fork Holston River (Virginia) Project

Feature Scores																																
Metric:	I				II				III					IV					V							VI						
Watershed Feature:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
Bear	3	5	3	3	5	3	3	5	NE	NE	3	5	NE	5	5	5	3	5	NE	NE	5	3	5	5	5	3	NE	NE	3	1	5	NE	NE
Hall	3	1	1	3	1	1	3	1	NE	NE	3	1	NE	1	1	1	1	1	NE	NE	1	1	1	1	1	3	NE	NE	3	5	3	NE	NE
Carlock	3	3	5	3	3	5	3	3	NE	NE	3	3	NE	3	3	3	5	3	NE	NE	3	5	5	5	5	3	NE	NE	3	1	5	NE	NE
Cedar	3	3	5	5	3	5	5	3	NE	NE	5	3	NE	3	3	3	5	3	NE	NE	3	3	3	1	5	3	NE	NE	5	5	1	NE	NE
Hutton	3	3	3	3	3	3	3	1	NE	NE	3	3	NE	3	3	1	3	3	NE	NE	1	3	1	1	5	3	NE	NE	3	5	1	NE	NE
Laurel	5	5	5	3	5	5	3	5	NE	NE	3	5	NE	5	5	3	5	3	NE	NE	5	5	5	5	5	3	NE	NE	3	1	3	NE	NE
Walker	3	5	5	3	5	5	3	3	NE	NE	3	5	NE	3	5	3	5	3	NE	NE	3	3	3	5	5	3	NE	NE	1	1	5	NE	NE
Upper MFH	1	1	1	1	1	1	1	1	NE	NE	1	1	NE	1	1	3	1	1	NE	NE	1	1	1	3	1	1	NE	NE	1	5	5	NE	NE
Hungry M.	3	3	5	3	3	5	3	3	NE	NE	3	3	NE	3	3	3	5	3	NE	NE	3	3	3	5	5	3	NE	NE	3	3	5	NE	NE
Nicks	5	5	5	5	5	5	5	5	NE	NE	5	5	NE	5	5	5	5	5	NE	NE	5	5	5	5	5	5	NE	NE	5	5	5	NE	NE
Staley	5	5	3	3	5	3	3	5	NE	NE	3	5	NE	3	5	5	3	5	NE	NE	5	3	5	5	5	3	NE	NE	3	5	5	NE	NE
No Name	5	5	3	3	5	3	3	3	NE	NE	3	5	NE	5	5	3	3	5	NE	NE	3	5	5	5	5	3	NE	NE	5	3	1	NE	NE
Greenway	3	3	1	3	3	1	3	3	NE	NE	3	3	NE	3	3	3	1	3	NE	NE	3	1	3	1	1	3	NE	NE	5	5	3	NE	NE
15 Mile	1	1	1	1	1	1	1	1	NE	NE	1	1	NE	3	1	3	1	1	NE	NE	1	3	1	1	5	1	NE	NE	3	5	3	NE	NE

Metric Scores												
Watershed	Drainage Area km²	Scenario: Metric:	Non-Runoff I	Non-Runoff II	Non-Runoff III	Runoff IV	Runoff V	Runoff VI	Scenario Scores: Non-Runoff	Scenario Scores: Runoff	Index Scores: WIPP	Index Scores: IBI
Bear	37.4		14	16	16	18	17	12	46	48	47	50
Hall	40.6		8	6	8	4	5	15	22	24	23	48
Carlock	18.7		14	14	12	14	17	12	40	43	41	44
Cedar	18.1		16	16	16	14	12	15	48	40	44	38
Hutton	29.7		12	10	12	10	9	12	34	32	33	32
Laurel	14.8		18	18	16	17	19	9	52	45	48	16
Walker	38.1		16	16	16	15	15	9	48	39	44	48
Upper MFH	78.7		4	4	4	6	5	15	12	26	19	42
Hungry M.	46.4		14	14	12	14	15	15	40	43	41	NS
Nicks	14.8		20	20	20	20	20	20	60	60	60	NS
Staley	36.7		16	16	16	17	17	17	48	51	50	NS
No Name	10.3		16	14	16	17	17	12	46	46	46	NS
Greenway	19.1		10	10	12	10	8	17	32	36	34	40
15 Mile	44.5		4	4	4	7	8	15	12	30	21	NS

NE = Not evaluated; feature not inventoried.
NS = Not surveyed.

The apparent disparity between IBI and WIPP is important. It clues the manager to do follow-up evaluations to better understand the system in order to take appropriate action. In the case of Laurel Springs Creek, fully reclaiming the stream would require biological stocking in association with land treatments. For the upper Middle Fork Holston, additional investigation (possibly monitoring) is needed to further define cause and effect relationships for that drainage. In the Hall Creek drainage, stream quality seems to be acceptable, so any NPS control activities will increase the level of protection for that stream. For the other watersheds, targeted treatment of NPS is recommended for those streams with low WIPP scores suggestive of high pollution potentials, or where low IBI scores indicate poor to fair stream quality.

Summary and Conclusions

WIPP, as presented in this paper, provides a framework to evaluate land uses and NPS pollution. It was developed in response to a need for a practical tool to

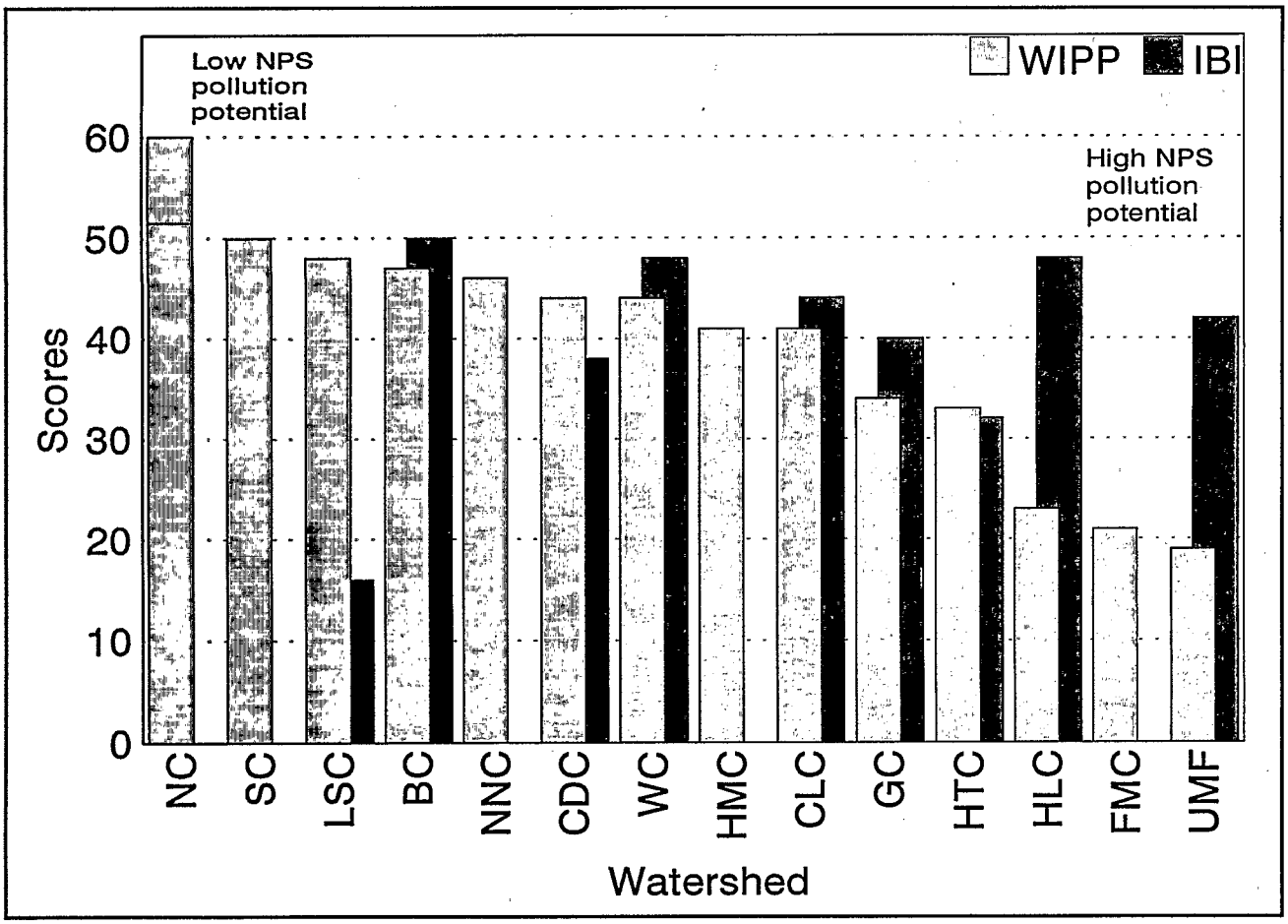

Figure 1. Comparison of WIPP and IBI scores for Middle Fork Holston River watershed (Virginia).

help guide monitoring, modeling, or NPS treatment needs in watersheds. WIPP is designed to extract as much information about land uses and NPS from remote sensed data to predict stream quality impacts. There are degrees of impacts between pollutant sources and stream impacts. No single index, data set, or model currently captures all the features and combinations of land-water relationships that occur in watersheds. But appropriately used tools can provide insight and guidance for appropriate follow-up action. Recognizing this reality, WIPP is just another tool. However, WIPP provides an effective bridge between land use and stream impacts via bioindicators. This greatly reduces the time and costs associated with extensive water quality monitoring before any decisions can be made about where to go and what to treat. Like other tools, WIPP can not, and should not, replace actual field familiarity with watershed conditions. Human reasoning is still the best tool to use to correct problems.

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A Managerial Model of Nutrient Flow from Forests in the Chesapeake Bay Watershed

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Our Situation

Now more than ever, policy makers, resource managers, and private citizens are faced with unprecedented opportunities and challenges. Human beings are influencing the natural systems of the earth as never before. Human needs and desires produce an appetite for natural resources and a need to dispose of wastes that is increasing exponentially. As natural resource use increases and wastes accumulate, states of ecosystem organization change and long-term stocks of many natural resources decline. Nowhere are these changes more significant than within the Chesapeake Bay watershed. These changes provide opportunities to develop new ideas and policies. They also present a challenge to rethink our relationships with the natural systems that surround us and to begin developing management strategies that help sustain the integrity of our ecosystems. New thinking can lead to highly leveraged and effective new policies.

Many of the natural resource management problems in the Chesapeake Bay watershed result from fundamental changes that are occurring in our social and environmental systems. For example, increasing human population is producing more demand for natural resources. Increasing desire for material goods creates a reinforcing cycle of need. More and bigger factories are built which consume natural resources more quickly and produce more material goods at faster rates. Increased production of material goods encourages the development of more physical capital. More roads generate more buildings alongside them, filled with more people, who need more roads. More roads create less open space, fewer trees, and lower environmental resiliency. They encourage emigration, stimulating more road building elsewhere in the watershed. Decisions made in a particular location at a particular time create consequences that are separate in time and space.

Often our policies within the Bay watershed focus on symptoms or pieces of a problem with only a fuzzy or incomplete understanding of the environmental and social interactions that are causing it. Our reactions to a problem may be ineffective due to distorted, delayed, or sequestered information, fear, or an unwillingness to face the truth. Even when we have good information and are willing to face the truth, we often produce policies that do not address the problem we have focused on because we lack understanding of the dynamics of the system causing the problem. We do not fully understand the detrimental effects our "solution" may produce. We may understand pieces of the system, but we often cannot sense the changes and delays caused by the intricate web of interacting factors embedded within it. Often, policies developed without an operational understanding of system structure and system dynamics produce consequences that are surprising, ineffective, or harmful.

As the pace of environmental and social change in the Bay watershed increases, the inadequacies of our incomplete, linear thinking become more difficult to

hide. Problems generated by past solutions appear more quickly. Our challenge is to see our watershed with new eyes (Marcel Proust, noted thinker and teacher); to realize that we need to understand the whole of our environmental and social system and the links between the "pieces" of the system—pieces we create in our minds. Just as the fragments of a shattered mirror produce a distorted image of the reality they reflect, focusing only on pieces of our environmental and social systems, while ignoring the whole, produces an incomplete picture of reality.

Systems-oriented thinking is needed to address resource management challenges in the Chesapeake Bay watershed. We must explore the consequences of proposed policies in a new way, using the paradigm of a system. The "pieces" of the policy system that change over time must be identified, along with links that show how each piece influences other pieces in the system. Policies may then be tested in this closed system of interacting component pieces. Relative changes over time produced by the interacting pieces of the policy system will show us the likely short- and long-term results of proposed policy decisions. Determining the relative changes that result from various policy scenarios will allow us to see how proposed policies change the condition and behavior of the watershed system overall. Alternative policies may then be more intelligently compared. The future will not be "predicted," but management choices for achieving a sustainable future will be identified.

What Are Managerial Models and Why Are They Useful?

A model is a simplified representation of reality (Meadows et al., 1992). Words, graphs, charts, and maps are models (Meadows et al., 1992). Our brains are pattern-seeking devices. They contain models of the world that we use to help us survive and make decisions. Our existence depends on an effective modeling of reality. The model described here is unique in that it attempts to capture an understanding of the system or operational structure producing a behavior of interest. An accurately defined operational structure allows testing the consequences of *new* policy decisions.

The model is a managerial model. It is designed to identify relative future modes of behavior that yield insights useful for management decision making, policy design, and creating a preferred future. It is not designed to replicate research data or generate precise predictions or conclusions about the future. This distinction is important. Conclusions are past events documented with data and data analysis. Research uses *past* events documented with data and analysis to generate conclusions. Managerial models are about *future* events that cannot be proved until after the event. Because they focus on future events, managerial models must identify the causal structure of the system producing the behavior of interest. This is essential because management decisions may *create new future conditions* that produce a system response different from past responses that may be documented by research (Boyce, 1985).

Questions

The managerial model described here is used to help understand forest nutrient dynamics. The model may be used in combination with other managerial models to assess the impacts of policy decisions on the Chesapeake Bay ecosystem. Specific managerial questions that the model is designed to investigate include:

- How does the relative release of forest nutrients in stream water change over time?
- How do the relative amounts of nutrients in forest streams change after forest clear cutting? When do these changes occur? How long do they persist?
- How quickly do changes in nutrient release from forest streams occur over the long term?
- What general effect does length of harvest rotation have on nutrient release?

A Model of Forest Nutrient Dynamics

Causal Structure

An understanding of causal structure at a level of detail appropriate for managerial insight and decisions can be achieved if system elements and time delays significant to system dynamics, and the linkages between them, are understood. A causal loop

diagram of the elements and linkages significant to this inquiry is shown in Figure 1.

The operational dynamics associated with long-term nutrient discharge from forest land may be described using the diagram in Figure 1. Oscillations in discharge result from the "shift in loop dominance" that occurs over time between the two linked casual loops shown in Figure 1. If forests are allowed to persist, a reinforcing cycle of nutrient uptake occurs. This reinforcing cycle is represented by the lower loop in Figure 1.

The forest produces more nutrient, which is used to produce more forest biomass. More biomass accumulates, producing more available nutrient. If all forest cover is removed and no vegetation is allowed to persist, a reinforcing cycle of nutrient loss occurs. This reinforcing cycle is represented by the upper loop of Figure 1. Nutrients are lost from the forest system. This reduces the amount of nutrient available for uptake by forest biomass and slows forest growth. Less biomass accumulates, producing less available nutrient. Short-term increases in nutrient release after clear cutting are due to the temporary suspension of the "nutrient uptake—forest vegetation" cycle. As new vegetation develops during the next growing season, the "nutrient up-take—forest vegetation" cycle begins again.

During suspension of the "nutrient uptake—forest vegetation" cycle, decomposition of organic matter continues. Nutrients accumulated in remaining forest biomass are not immediately flushed from the system. This delay helps create a peak discharge of nutrients a few years after timber cutting.

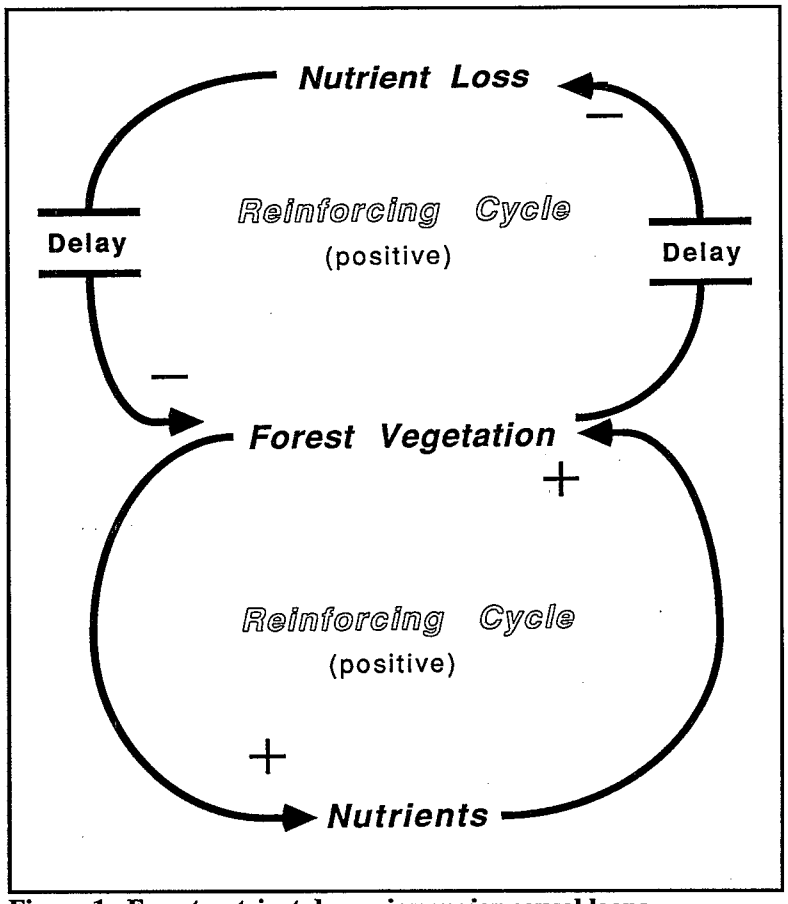

Figure 1. Forest nutrient dynamics: major causal loops.

Nutrient Dynamics with No Harvest

The managerial model suggests that nutrients continue to accumulate in forest vegetation even as growth rate slows. Gradually, nutrient losses increase slightly. Nutrient uptake and nutrient loss reach a dynamic equilibrium. Figure 2 illustrates this effect. Nutrient uptake continues to increase, at a decreasing rate, even as forest vegetation has reached the upper end of an S-shaped growth rate pattern.

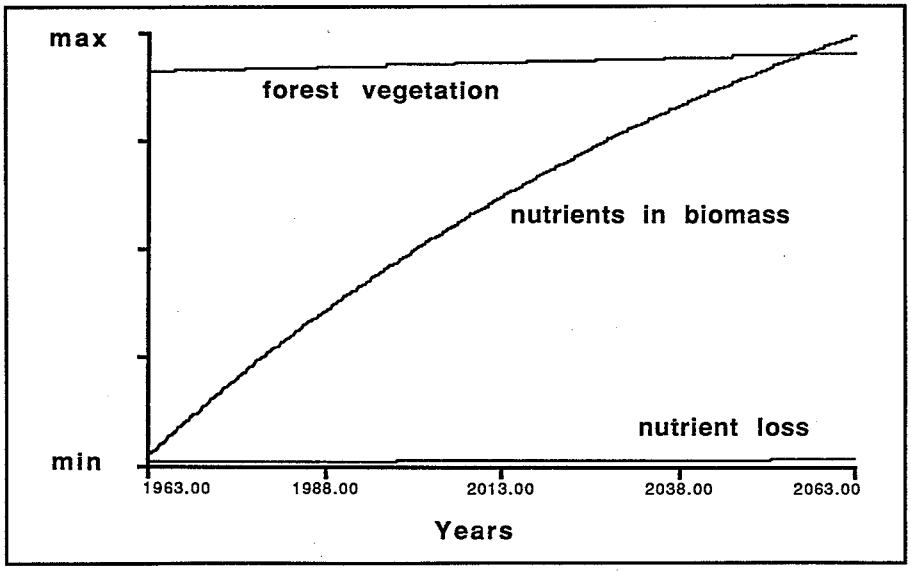

Figure 2. Nutrient dynamics: no harvest.

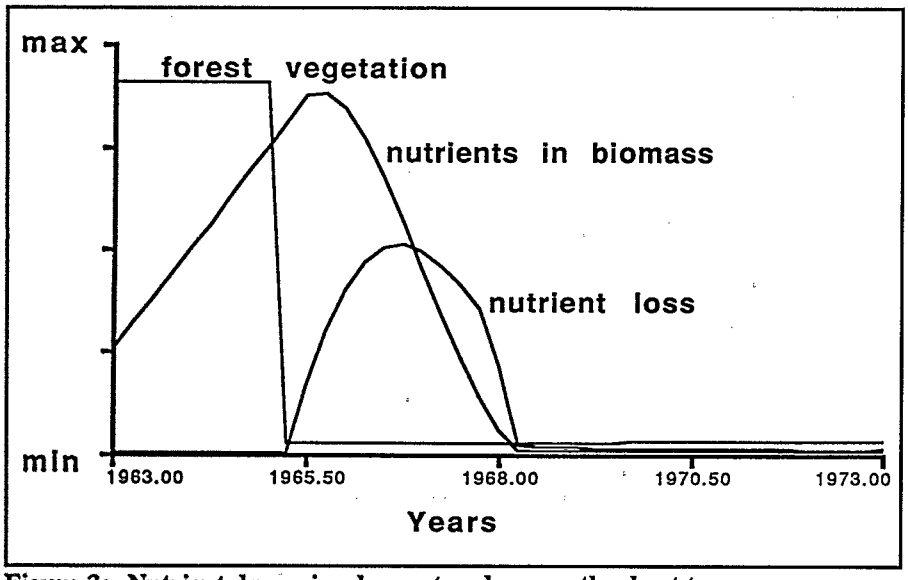

Figure 3a. Nutrient dynamics: harvest and regrowth: short term.

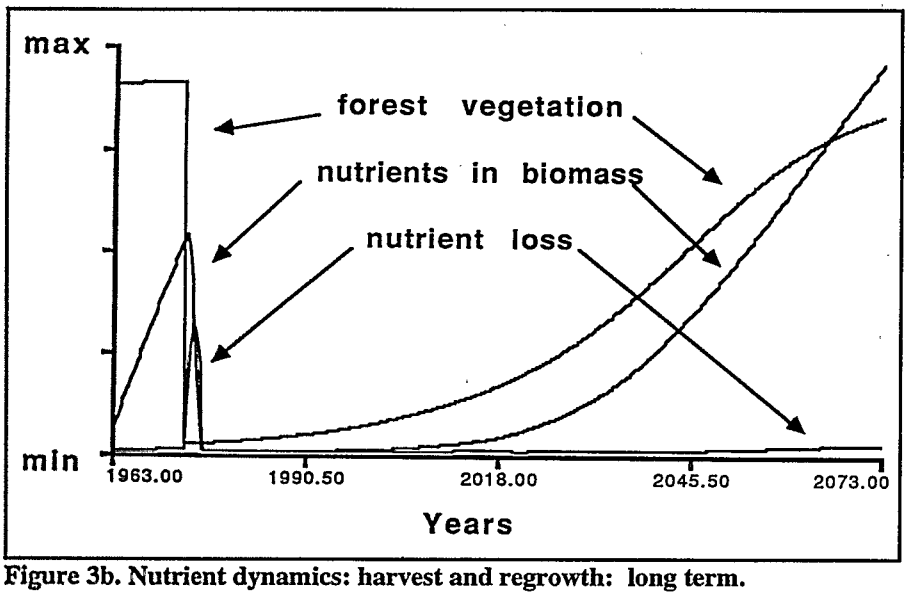

Figure 3b. Nutrient dynamics: harvest and regrowth: long term.

The amount of nutrient released and lost in stream water also increases. Large amounts of nutrient are accumulated in forest biomass. Over time, nutrient uptake and nutrient loss reach a dynamic equilibrium.

Nutrient Dynamics with Harvest and Regrowth

The managerial model of nutrient flow produces a different response if clear felling of trees occurs. Clear cutting trees produces a large stepwise reduction in forest vegetation. The loss of living biomass briefly interrupts the cycle of nutrient uptake and accumulation in forest vegetation. Nutrients previously available for cycling in living biomass are made available to be flushed from the forest system. While nutrients are available for release immediately, periodic rain fall causes a delay of a year or two in peak discharges of nutrients to stream water. New vegetation quickly reestablishes the cycle of nutrient uptake and accumulation in forest biomass, and the amount of nutrient released from the system declines rapidly. This mode of forest system response has been demonstrated by Likens et al. and is shown by model output in Figure 3a.

As forest regrowth continues after timber harvesting, nutrient loss diminishes quickly and the amount of nutrient accumulated in biomass increases. A large stock of nutrient is accumulated in forest biomass. As growth of forest vegetation begins to reach dynamic equilibrium, small increases in nutrient loss occur. This mode of system behavior is illustrated by the model output in Figure 3b.

Nutrient Dynamics with an 80-Year Harvest Cycle

Model output suggests that the amount of nutrient released during forest clear cutting may be proportional to the volume of forest vegetation present and the frequency of the harvest cycle. Variations in site characteristics, vegetation types, and harvesting methods undoubtedly affect the amount of nutrient released. However, all else remaining equal, a larger "pulse" of nutrient will be released when areas containing a larger volume of forest vegetation are harvested. Since a nutrient pulse is released at the time of clear cutting, more frequent clear cutting results in more frequent releases of nutrient pulses.

This mode of system behavior is illustrated in Figure 4. An older mixed mesophytic forest is assumed to be

harvested and placed on an 80-year cutting cycle. Using "identical" harvesting methods the first clear cut harvest produces a pulsed release of nutrient into stream water, larger than the second pulse generated by clear cutting 80 years later. However, the model does not determine if "the amount of nutrient released per unit of biomass removed" is more or less during the first or second harvest. The model only generates the general mode of behavior.

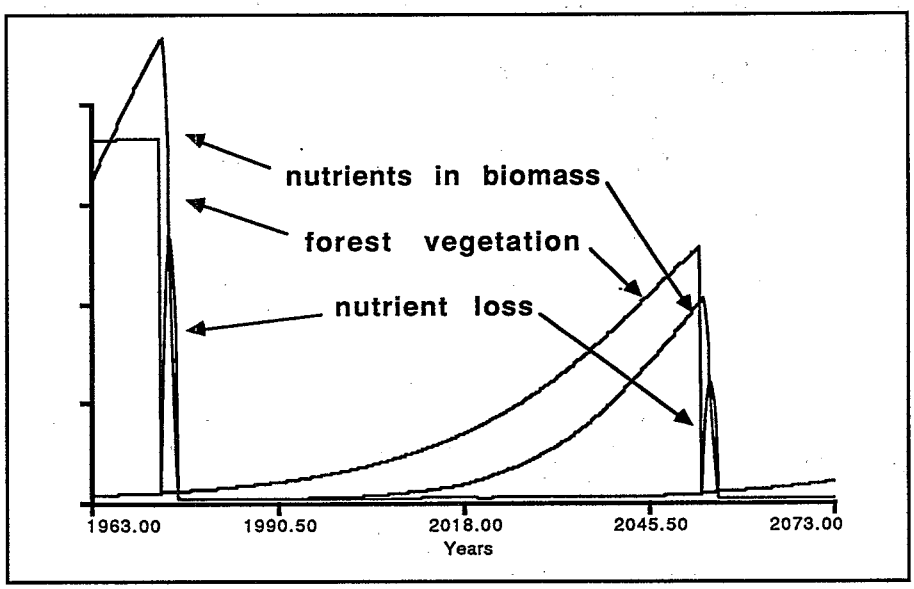

Figure 4. Nutrient dynamics: 80-year harvest cycle.

Conclusions

The managerial model of nutrient dynamics produces useful insights into the long-term operational dynamics of nutrient cycling in mixed mesophytic forest systems of the eastern United States, and changes in nutrient release affected by clear felling of trees. This is because the dynamics and structure of the system are studied. A simulation of system dynamics based on an operational understanding of system structure often produces more useful information for management decision making than analysis of static parameters with unknown structural relationships. Some of the insights generated by the model are listed below.

- Clear felling of timber may result in a delayed, pulsed release of nutrient into forest stream water. Discharge diminishes quickly as new forest vegetation reestablishes the cycle of nutrient uptake and storage in forest biomass.
- The amount of nutrient released into forest stream water during forest clear cutting may be proportional to the volume of forest vegetation present and the frequency of the harvest cycle. This suggests that longer harvest rotations may help reduce the total amount of nutrient released into forest streams over time. Variations in site characteristics, vegetation types, and harvesting methods undoubtedly affect the amount of nutrient released. The model does not address these relationships. Also, the model does not determine if "the amount of nutrient released per unit of biomass removed" is more or less during successive timber harvests.
- Large stocks of nutrients accumulate in forest biomass over time and nutrients continue to accumulate in mature forests, gradually approaching a dynamic equilibrium. This suggests that longer harvest cycles may enhance the long-term effective-ness of forests as "sinks" for accumulation and storage of nutrients.

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Implementing a Watershed-Analysis-Based Approach to Timber Management Planning in the Hoh River Basin, Western Olympic Peninsula, Washington

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Rural watersheds throughout the Pacific Northwest have faced dramatic landscape changes during the past two decades. Population growth, at rates much greater than the national average, continues to push the margins of urban centers outward into rural areas that traditionally have supplied the Nation with a substantial percentage of its wood fiber. Increasingly, the more remote, mountainous watersheds must grapple with a variety of competing social and economic pressures imposed by the burgeoning population's resource demands. These include needs for increased production of wood and water; more land for recreational and residential use; improved commercial-forest aesthetics; and greater environmental protection of the region's fish, wildlife, and cultural resources.

In Washington State, where 52 percent (22 million of 43 million acres) of the land base is forested and 77 percent of that is commercially harvestable (WA DNR, 1992), intensified logging activity has heightened concerns over the potential physical and biological impacts of timber harvesting on watershed health. At question are the cumulative effects of multiple harvest activities on watershed erosion and sedimentation, fish and wildlife habitat, stream riparian functions, and water quality. Upland forest practices have been scrutinized and monitored closely by a number of different resource-use groups, in particular by Native American Indian tribes that rely, both economically and culturally, on healthy salmon runs in coastal river systems. A primary forestry issue today, therefore, concerns the relationships between logging practices, the accompanying ground disturbance that leads to erosion of hillslope soils and sedimentation of adjacent stream channels, and salmon habitat.

Purpose

This paper provides a case study of a remote, mountainous watershed on the Olympic Peninsula in northwestern Washington. It highlights the attempts of a multi-affiliated group to resolve conflicts between timber-harvest and salmon-habitat management needs in a basin that has been largely converted from old-growth to young-aged forests during the last 25 years. My purpose is twofold: (1) to describe the watershed-condition issues that led to the formation of this interagency science-and-management team and (2) to present the adaptive management plan that we have created and implemented to address these concerns. This program represents a new concept in management of Washington state-administered timberlands because it employs scientifically based, landscape-scale planning in its daily timber-production

business, an important change from the traditional approach of planning by individual forest stand or harvest unit. Also, it seeks to diminish past conflicts through a cooperative agreement with other watershed resource managers, which is designed to address the long-term requirements for protection and rehabilitation of the basin's natural resources.

Background

The Hoh River watershed, located on the west side of the Olympic Peninsula (Figure 1), supports one of three temperate rainforests on the North American continent. The mild, wet climate promotes dense coniferous growth dominated by western hemlock, Douglas fir, western red cedar, and Sitka spruce. The productivity rate per unit area of these forests exceeds that found anywhere else on earth (Kirk, 1992).

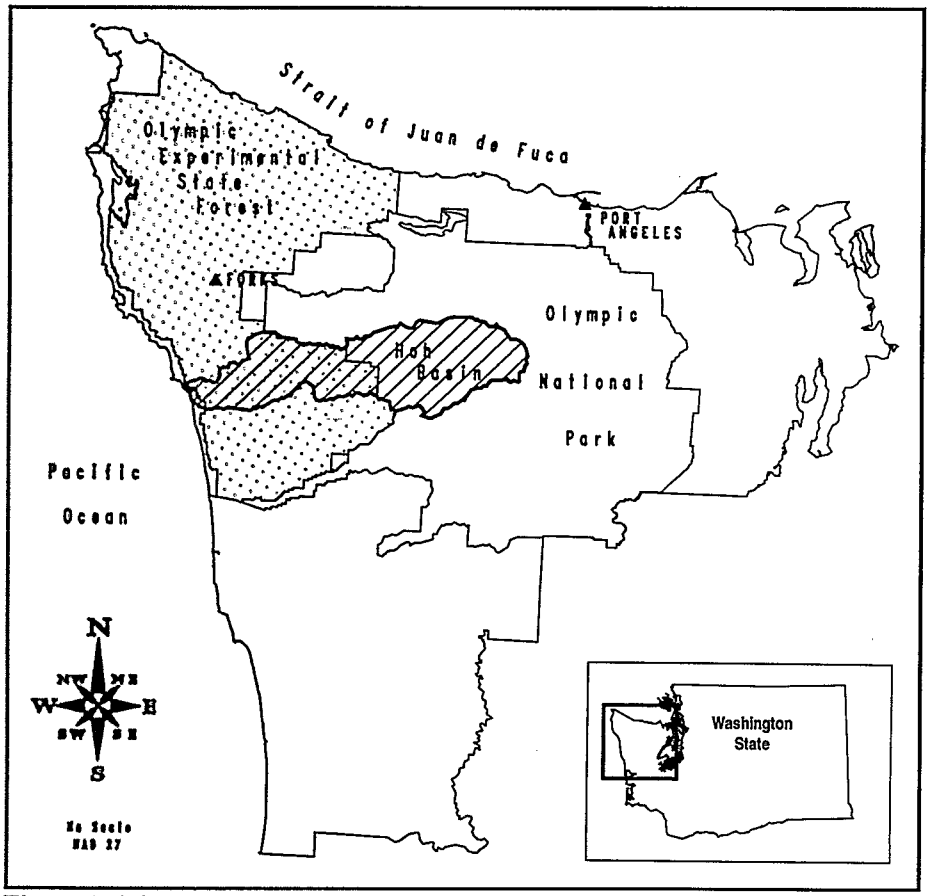

Figure 1. Map showing location of the Hoh Basin study area and its geographic relation to the proposed Olympic Experimental State Forest, Olympic Peninsula, Washington.

Consequently, the rainforest draws international attention not only for its unique ecological values but also for its abundant, high-quality timber. From its glacially fed source in the interior of the Olympic Mountains, the Hoh River flows 100 kilometers (km) westward through a patchwork of land ownerships, each with a different administrative mandate. The upper watershed, roughly 58 percent of the 776-km^2 drainage area, is administered by Olympic National Park for wilderness resource protection and recreation. The lower 41 percent of the watershed is managed by the Washington State Department of Natural Resources (DNR) and by private landowners as commercial timberlands. DNR forest lands, comprising 47,000 acres here and 2 million acres elsewhere across the state, are managed to provide long-term income for Washington's schools, counties, and other public trust beneficiaries. On these and private timberlands, however, three additional state agencies regulate other natural resources, including fish, wildlife, and water (i.e., the Washington Departments of Fisheries, Wildlife, and Ecology, respectively). The Hoh Indian Nation, occupying 0.3 percent of the watershed at the river mouth, depends primarily on healthy, wild salmon and steelhead runs in the Hoh and adjacent systems for its subsistence, livelihood, and culture. These fish stocks also contribute to a lucrative coastwide fishing industry. Coho and chinook salmon, as well as steelhead trout, primarily rear and spawn in Hoh side-channel and valley-wall tributary gravels on commercial timberlands and for a short distance upstream of the Olympic National Park boundary (Sedell et al., 1984; Schlichte et al., 1991).

Numerous studies throughout the Pacific Northwest have documented a cause-effect relationship between timber-harvest activities and landsliding, due to some combination of (1) reduced root reinforcement from wood decay and soil disturbance;

(2) changes in the volume and timing of water input to the soils from decreased evapotranspiration, transient snowmelt, and surface runoff rerouted and concentrated by road drainages; (3) failure of road sidecast and landing deposits resulting from material loading and/or decay of incorporated woody debris; and (4) reactivation of old mass-wasting sites through disturbance (Sidle et al., 1985). Observations of mass-wasting events in unmanaged forests within the Hoh River drainage suggest that natural landslides occur frequently due to a combination of steep glaciated terrain, highly erosive substrates derived from deeply weathered sedimentary bedrock and glacial deposits, heavy annual precipitation (350-500 cm/yr), and active continental-margin tectonics. Preliminary data from managed lands in the lower basin (Schlichte et al., 1991; Shaw et al., in preparation) and from the nearby North Fork Calawah watershed (O'Connor and Cundy, 1993) indicate an order-of-magnitude increase in rates of mass wasting following logging and road-building activities, mainly through the mechanisms summarized above. A large fraction of these post-harvest failures, however, occur in hillslope locations that are naturally prone to instability, many of which show signs of ancient mass movements.

The effect of landslide-related stream sedimentation on salmonid spawning and rearing success is not yet fully documented. However, several studies in the Hoh and adjoining watersheds (e.g., Cederholm and Salo, 1979; Schlichte et al., 1991) demonstrated that sidecast-constructed and poorly maintained roads caused mass wasting and significant sedimentation of spawning gravels, particularly in side-, terrace-, and valley-wall tributaries to the third- and fourth-order mainstem channels. Additional research (e.g., Cederholm and Reid, 1987) found that landslide-contributed silt in stream gravels was detrimental to survival of salmon eggs and fry, as well as to macroinvertebrate populations on which salmonids prey (Schlichte et al., 1991). Moreover, ongoing comparative studies between stream channels in managed and unmanaged watersheds (Hatten, in preparation) show that channel segments with sparse or no riparian forest can develop damaging to lethally high water temperatures during the summer months.

During the winter of 1989-1990, a series of high-intensity, long-duration storms triggered significant landsliding and associated debris flows throughout the western Olympic Peninsula. In April 1990, the Hoh Tribe requested deference of a state timber sale in the Hoh drainage because of nearby debris-flow activity and increased sediment loading of downstream fish habitat. Recognizing the importance of a cooperative investigation of these concerns, as well as of other forest-management issues described above, the Department of Natural Resources, Hoh Tribe, and Northwest Indian Fisheries Commission entered a year-long study to evaluate the impacts of state timber-management activities on mass wasting, peak storm flows, surface and road erosion, channel morphology, and fisheries habitat (Schlichte et al., 1991). In 1991, two additional teams were formed. The first was charged with creating and implementing a timber-management plan for state lands within the watershed, based on conclusions garnered from these and ongoing investigations of physical, biological, and silvicultural processes. The second team's task was to carry out stream restoration projects, while the DNR engineering division began an extensive road stabilization project to remove unstable, debris-flow-generating sidecast deposits from logging roads in the basin. These teams went to work, while the state imposed a moratorium on its timber harvest, pending development of the management plan. Finally, in February 1993, the state and Hoh tribal governments both placed their votes of confidence in this process by signing a Memorandum of Understanding to follow the watershed analysis techniques and administrative policies as set forth in the Hoh Timber-Management Plan.

Management Plan Objectives and Methods

The stated objective of our watershed program is to promote management alternatives that will both protect and restore viable fish habitat and water quality on public trust lands in the Hoh drainage (WA DNR, in preparation). Developed under the auspices of the Olympic Experimental State Forest, which was proposed in 1988 by the state governor's Commission on Old Growth Alternatives for Washington's Forest Trust Lands and currently is pending state and federal approval, our plan carries with it the experimental forest's more global objective.

Its mandate is to develop, at the landscape scale, management alternatives that will maintain old-growth forest characteristics in commercially harvested timber stands without jeopardizing key ecological values associated with old-growth communities (WA DNR, 1991). Simultaneously, legal obligations (i.e., income generation) to the land-trust beneficiaries must be met. Accomplishment of these goals entails a combination of research; silvicultural manipulation of stand structures to enhance species, genetic, habitat, and ecosystem diversity; long-term monitoring; and adaptive planning on time scales longer than the average rotation between harvests (e.g., 60-120 years).

The concept of forest-landscape planning is central to these objectives of protecting, restoring, and maintaining the ecological integrity of commercial timberlands. In the past, harvest planning on the Olympic Peninsula relied primarily on evaluating local conditions within the 40-140-acre harvest units. Ecosystem perspectives were rare, partly because scientific understanding and methodologies to assess watershed or landscape cumulative effects were largely academic, or operationally incomplete. Now, with the last decade's surge in Northwest-watershed research and improved harvest technologies, agency landowners on the peninsula have begun to plan for future forest conditions at the fourth- and fifth-order watershed scale. In many of these watersheds, however, the imprint of previous harvest rates and methods limits our capability to alter landscape patterns on short or intermediate time scales (i.e., less than one harvest rotation). In the Hoh watershed, 65 percent of the DNR-managed old-growth forest has been roaded and logged since the early 1960s. The remaining, currently harvestable forest lies scattered between predominantly 2-20-year-old tree plantations, connected by a high-density road network. These factors, particularly road locations, constrain ecologically based, short-term manipulations of the landscape and make planning efforts more difficult. Our challenge now is to determine how best to manage these remnant old-growth stands in a manner that will not further degrade current watershed physical and biological conditions, how to develop and implement long-term methods for enhancing ecosystem diversity on the second-growth acres, and how to accomplish these goals while meeting the trust mandate.

Our plan is designed as an operational tool for the DNR foresters and land managers to use in guiding timber management on state lands. Many of the watershed evaluation procedures have been tailored so that field foresters developing timber sale proposals can conduct them while already in the field. Field data are then analyzed in consultation with staff scientists. While we have no jurisdictional authority over other timber landowners in the basin, watershed analyses are performed regardless of ownership boundaries. The guide consists of a manual, with accompanying maps, that leads the user through a series of procedural steps. Decisions made at each step dictate which successive ones to take.

Our interagency team acts as a scientific and technical advisory group to the foresters and land managers as they work through this process. We use a combination of remote-sensing techniques, field visits, and qualitative and/or quantitative models to identify and evaluate biological and physical processes within our watershed. We then use defined threshold values for these parameters as criteria for making management decisions; threshold values are based on the literature, statute, or best available information from the Hoh drainage. While many physical and biological processes are ubiquitous, our model is predicated on the particular combination of Hoh landscape processes and the cumulative effects of timber harvest in them. Therefore, while the model is transferable to other landscapes, the watershed threshold parameters, on which management decisions are based, may change from one river basin to the next. Map overlays provide an effective method for visualizing the spatial relationships among physical and biological features, where sensitive resource areas (e.g., those with a high mass-wasting potential) are readily apparent and can be treated specially with harvest restrictions, preventive or restorative measures, and further monitoring. Subtraction of unharvestable acres from the timber-base acreage allows managers to adjust harvest estimates for future economic planning.

DNR foresters, whose primary duties consist of designing and laying out timber sales, must now qualify their harvest proposals through the procedures described below. These proposals need to demonstrate

that no significant changes to hillslope stability and hydrologic regimes, which could potentially damage stream channels supporting fish habitat, will result as a consequence of harvest activities.

Management Plan Implementation

This adaptive, watershed-analysis-based timber management program is the first of its kind to be implemented by a Washington State agency to manage the cumulative effects of logging on public lands. It has been used in the Hoh River drainage since April 1992.

The conceptual outline for the evaluation process is shown in Figure 2. Its foundation is a site hazard-and-risk assessment procedure that weighs the potential for resource impacts by a proposed timber sale against known hazards posed by natural and harvest-impacted hillslope processes within the hydrologic basin containing the sale. Based on the assessment outcome, management prescriptions may vary from standard methods for clearcutting and road-building, to total or partially restricted harvest, the latter of which might include selective tree harvest by impact-minimizing techniques (e.g., by helicopter). Regardless of the prescribed activity, conditions within the harvest unit and hydrologic basin are monitored to determine the management strategy's effectiveness. Physical and biological watershed components will be re-evaluated every 2 to 5 years, depending on the rate of observed changes in their conditions. This will allow us to analyze and modify our working assumptions regarding watershed processes, our scientific techniques and decision-making criteria, and our management practices. It will also aid us in developing basic and applied research projects to resolve problematic technical and management issues.

The principal land unit on which this watershed analysis occurs for any given timber sale is the second- or third-order tributary basin most immediately connected to it. These hydrologic basins generally range from 500 to 5,000 acres in size. Tributary-basin analyses are then linked across the larger Hoh landscape to ascertain the cumulative effects of management on the mainstem watershed as a whole. This program emphasizes the prevention of upslope impacts; that is, the analysis does not rely on the presence of fish-habitat damage as the burden of proof that upland practices are unacceptable.

Timber sales proposed within a given tributary basin are analyzed following the procedure outlined in Figure 3. The basic elements, denoted with circles, consist of: (1) a hillslope "hazard" analysis, summarizing mass-wasting and surface or road erosion potential, as well as the geomorphic characteristics promoting substrate instability; (2) a slope hydrology analysis, which estimates changes in basin water production following timber harvest; (3) a physical and biological channel-condition assessment that evaluates the potential for physical channel-changing events and fish-habitat degradation resulting from upslope management activities; (4) short- and long-term monitoring of prescription effectiveness and methodological validity; (5) a process for recommending habitat protection and restoration projects to the interagency task force responsible for designing and imple-

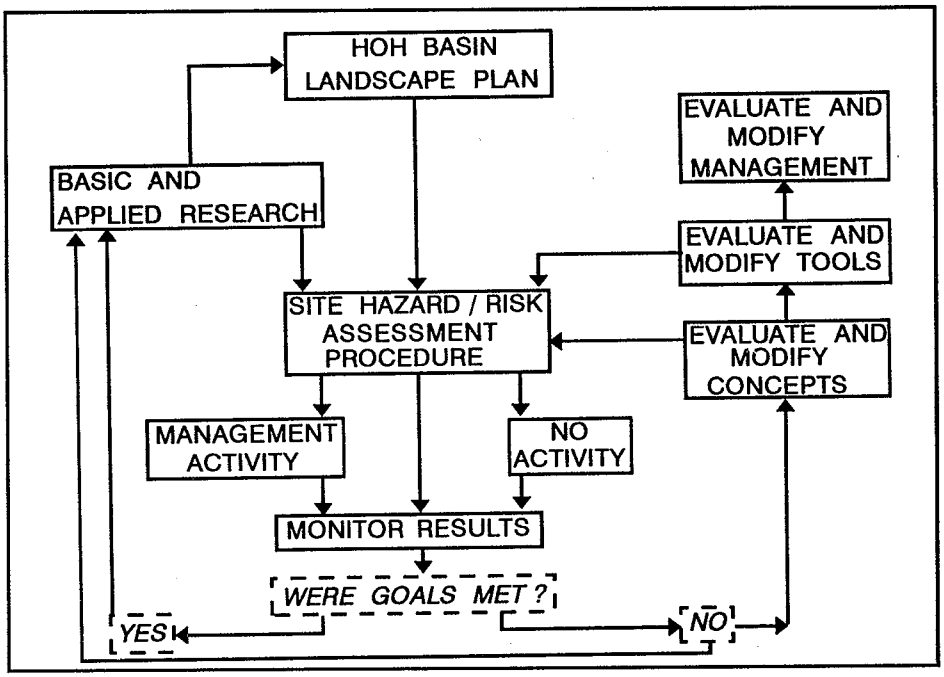

Figure 2. A conceptual outline for the adaptive, landscape-level, timber-management plan currently being implemented on DNR-managed lands within the Hoh watershed.

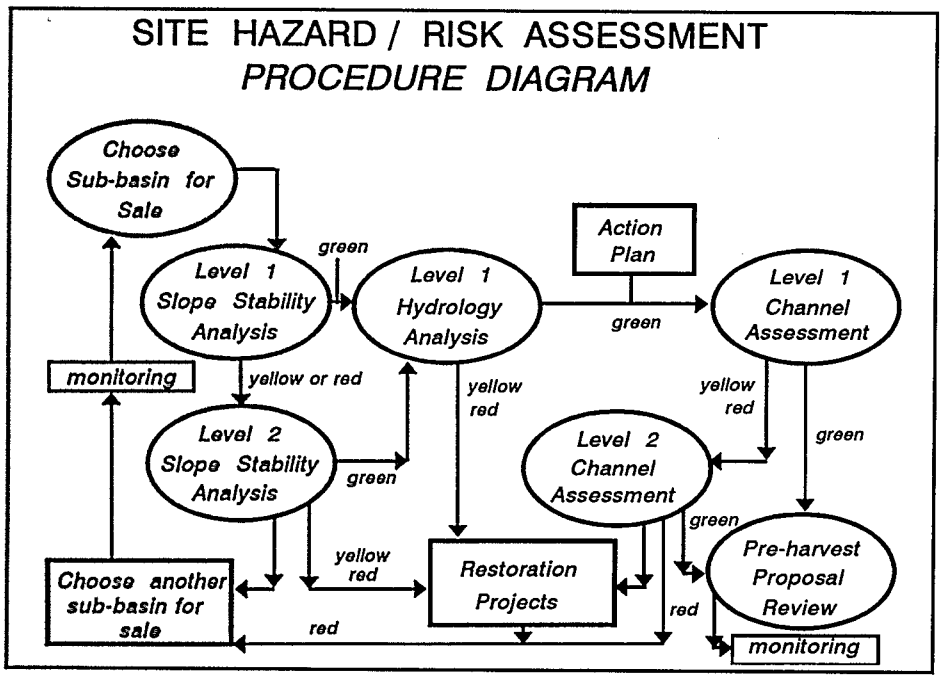

Figure 3. Management decision-making procedure diagram; circles denote technical watershed-analysis steps, arrows show decision pathways (see text), and boxes indicate actions taken. A timber-sale proposal is approved following the pre-harvest proposal review.

menting them; and (6) a pre-harvest review period, allowing our cooperators and other interested parties the opportunity to comment on approved proposals. These basic steps are considered "Level 1", or broad-perspective, procedures. "Level 2" steps involve more intensive, quantitative analyses of slope and channel parameters, necessary to evaluate watershed conditions that have met or exceeded our defined critical thresholds for potential adverse effects. The pathway between steps is shown in Figure 3 by arrows; passage from one process to the next depends on whether a given watershed parameter is in satisfactory or critical condition. Our threshold criteria are denoted by colors used on accompanying maps to describe areas where these conditions exist. An idea borrowed from the one stoplight on the western Olympic Peninsula, "green" denotes that potential watershed-process hazards or resource risks are low and the proposal "passes" this phase of the analysis, "yellow" indicates an intermediate concern for which further detailed analysis and timber-proposal modification are needed, and "red" means that critical conditions exist that will significantly constrain or dismiss the proposal.

Each analysis phase (e.g., diagram circle) utilizes watershed information that has been summarized and displayed as map overlays. A minicomputer-based geographic information system (GIS) has been invaluable for the storage, display, summary, analysis, and integration of geographic data. These data are compiled through remote sensing and field inventories carried out by a consortium of DNR foresters and technical staff, and Hoh tribal staff. The basic sources of information for the Level 1 slope hazard-zone analysis are a series of maps showing (1) topographic, drainage network, and road data; (2) forest age-class distribution; (3) mass-wasting, surface erosion, and road problem sites, which correspond to inventory information describing their relationship to geological, geomorphological, hydrological, and land-use characteristics; zones of higher or lower failure potential are scribed around these points; (4) geomorphology, including soil-type distribution, hillslope form, soil depth-to-bedrock, and vegetative rooting depths, all of which govern mass-movement probability and behavior; and (5) slope morphology, or the combination of slope gradient and form (i.e., convex vs. concave) that may promote or resist soil mass movement. Each of these layers uses the "stoplight" color scheme to alert map users to areas where critical thresholds are exceeded. For example, most observed landslides that have triggered debris flows occur on slopes with a concave form, whose gradient exceeds 25° (48 percent); these areas are colored red on the slope-morphology overlay and encompass mass-wasting potential sites shown on the slope-failure overlay. The Level 1 hydrology analysis is performed using a quantitative average annual water yield model, as well as field observations of potential hydrologic problems associated with road drainage and channel obstructions. Level 1 physical and biological channel-condition assessments double as basin-monitoring and proposal decision-making tools. They include (1) a field assessment of physical channel morphologies and rates of change associated with hydrologic peak-flow events and de-

bris-flow impacts (modified from several procedures, including Jones and Stokes, 1992); (2) a field assessment of riparian conditions, which includes an analysis of stream-shade conditions for water-temperature regulation and an assessment of the potential for stream segments to recruit large logs from the riparian forest for channel-stabilizing and habitat-providing purposes (from WA Forest Practice Board, 1992); (3) a field evaluation of fish habitat and usage patterns, as well as future habitat and fish-production potential; and (4) an aerial-photograph and field assessment of material routing from existent and potential mass movement sites to resource-sensitive channel reaches. Historical aerial photographs are particularly effective analysis tools in this basin, as they were taken prior to the onset of intensive timber harvest.

The Level 2 channel-condition assessment involves more quantitative approaches to analyzing stream parameters, including (1) monitoring stream water temperatures, gravel composition, and channel geometries, to precisely locate and describe conditions damaging to fish habitat; (2) peak-flow hydrograph modeling to predict storm-specific changes to channel-forming flows; (3) sediment-budget analyses; and (4) coupled peak-flow and predictive sediment-transport algorithms to calculate the potential for channelized sediments to be remobilized by seasonal or storm-generated high flows. The Level 2 slope-stability analysis comprises a geotechnical model that utilizes field data and factor-of-safety analyses for heterogeneous soils, variable ground-water conditions, and nonuniform failure surfaces.

Many of these techniques supply us with data for baseline and effectiveness monitoring. In particular, the channel-assessment methods have been developed so that data acquired can be used to evaluate future temporal and spatial variability in channel conditions. Upslope areas are monitored via regular aerial surveys, and a harvest-site evaluation form is used to document potential changes in hillslope conditions. In addition, comparative studies and monitoring of watershed processes within Olympic National Park have begun (e.g., Hatten, in preparation), which will help us test and adapt parameter threshold criteria used in the watershed-analysis process.

Eight timber-sale proposals currently are being passed through this program. So far, the effects on our timber-sale activities have been (1) removal of inherently unstable ground from harvest proposals; (2) restriction of harvest from wet, unstable parts of the hillslope; (3) limitations on harvest systems that promote soil disturbance (e.g., ground-based yarding systems); and (4) enlarged channel buffer zones to protect riparian areas. Meanwhile, the interagency habitat-restoration team has undertaken three major projects in the basin, building side-channel fish escapement ponds to replace habitat damaged through debris-flow activity in valley tributaries.

Conclusions

One of the most critical challenges confronting timber managers today on the Olympic Peninsula, and elsewhere in the Pacific Northwest, is how to evaluate, measure, and monitor the effects of forest harvest on other important watershed resources. Especially in drainages like the Hoh River, where demands for commercial forest products, wilderness, salmon fisheries, and water quality interests converge, overlap, or conflict, accountable and repeatable methods for assessing effects of resource use on landscape ecosystem health are essential. The management model described herein seeks to fill this need for state lands in the Hoh River drainage of the Olympic Peninsula and serves as a prototype method for watershed-analysis-based, forest-landscape planning efforts going on elsewhere on DNR-managed trust lands.

Developed by an interagency, interdisciplinary team, this adaptive-management program currently is being implemented on state trust lands within the Hoh watershed. Goals of this process include (1) developing short- and long-term timber harvest plans based on objective evaluations of the potential for management activities to accelerate hillslope erosion, increase flooding, degrade water quality, alter stream-channel morphology, and change fish-habitat conditions; (2) designing and implementing baseline and effectiveness monitoring critical for evaluating timber-harvest prescriptions and adapting management practices to new technical information; and (3) creating new techniques for analyzing watershed processes, where inadequate or nonexistent methods existed before. Presented as a stepwise decision-making

manual with accompanying maps, these tools are being used in the field by state foresters to design timber sales around hillslope and channel concerns. Through adaptive implementation of this plan, we are continually learning new ways to improve technical methods, utilize GIS capability, integrate forester staff into watershed-analysis procedures, automate the decision-making process, and better manage timberlands for the benefit of watershed resources.

Acknowledgments

The following people compose the Hoh watershed-program team and deserve full acknowledgment for their critical roles in this process:

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Randy Mesenbrink, Hoh District Manager, WA Dept. of Natural Resources
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Susan Shaw, Geomorphologist, WA Dept. of Natural Resources
Eric Shott, Fish Biologist, Northwest Indian Fisheries Commission
Alan Vaughan, Team Chair, Intensive Management Forester, WA Dept. of Natural Resources

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The Watershed Approach for Protecting Vermont's Water Quality

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Vermont's single greatest water quality concern is to protect and restore its beautiful lakes and ponds. There are over 280 lakes and ponds with surface areas of 20 acres or more in the state. These areas are heavily used for fishing and recreation. They are nestled in the pastoral and mountain landscape and provide a main attraction for tourism. Unfortunately, 39 of the state's lakes and ponds, including the two largest—Lake Champlain and Lake Memphremagog—have serious eutrophication problems (VT 305(b) Report, 1992). Problems related to depressed water quality vary from beach closures to declining use for recreation, fishing, and general shoreline enjoyment.

Vermonters recognized these water quality problems early. Prior to 1970, most protection measures were directed toward point source controls. Then in the early 1970s, framework planning for related land resource management became important. One example was the initiation of the Lake Champlain Level B Study that culminated in publication of a 1978 basinwide management plan.

Watershed as the Management Unit

For more than 50 years, the U.S. Soil Conservation Service (SCS) has recognized the importance of the watershed unit for evaluating problems and for planning and implementing water and related land resource protection measures. As land-related water quality problems gained attention in Vermont, SCS advocated planning within watershed units as the logical approach.

Vermont's water resources lie within four principal basins: Connecticut River, Lake Champlain, Lake Memphremagog, and the Hudson River. SCS has further subdivided these basins into 11-digit hydrologic units or watersheds (generally 400 square miles or less in size) to facilitate hydrologic analyses and provide for watershed sizes that are appropriate for U.S. Department of Agriculture (USDA) program assistance. There are 99 of these watersheds in Vermont (Figure 1).

The Lake Champlain Level B Study completed in 1978 was the first comprehensive study in Vermont that analyzed watersheds for water quality problems and solutions. SCS participated through a study of the LaPlatte River Watershed that was used as a sample to characterize agricultural nonpoint source runoff and management needs in the basin.

Later in 1979, SCS authorized the LaPlatte River Watershed as the Nation's first Public Law 83-566 Project to exclusively implement land treatment measures on a watershed basis for the protection of water quality. The project provided for treatment of agricultural runoff on 26 dairy farms to protect the water quality of Shelburne Bay, a major embayment of Lake Champlain.

Monitoring and Evaluation

The LaPlatte River Watershed Project included a 10-year-long major component for comprehensive water quality monitoring and evaluation. In 1980, USDA authorized the St. Albans Bay Watershed Experimental Rural Clean Water Project. This project used

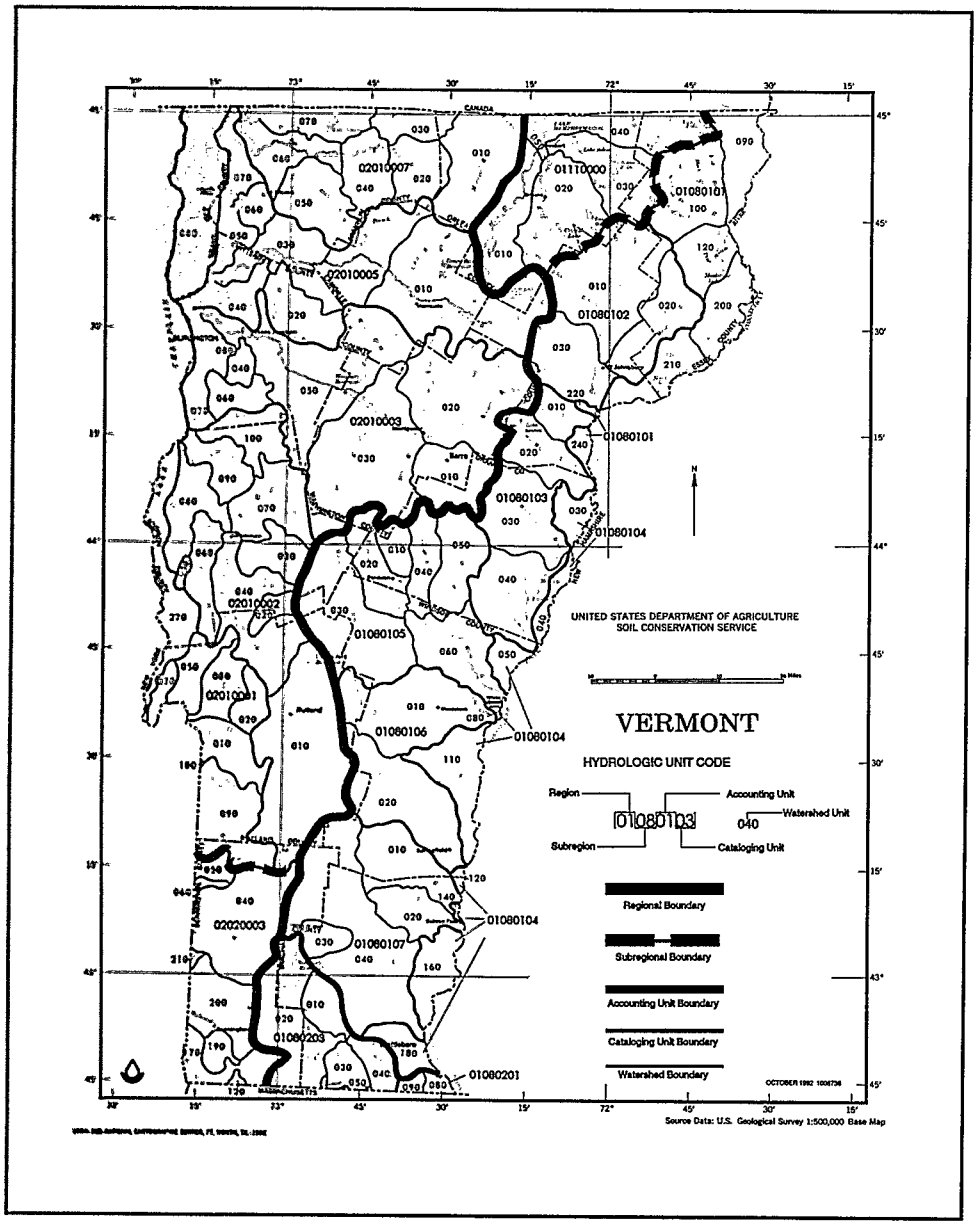

Figure 1. Watershed map of Vermont.

a watershed approach to treat 66 out of 100 of the watershed's farms; a major component was comprehensive monitoring and evaluation over a 10-year period.

Both of the water quality monitoring and evaluation efforts were conducted by the University of Vermont in cooperation with SCS and the U.S. Department of Agriculture's Agricultural Stabilization and Conservation Service (ASCS). The results of these projects have been extremely helpful in the calibration of special computer models and in the revision and development of technical standards for best management practices (BMPs). For example, SCS completely revised its Code 393 Filter Strip standard because the monitoring activities identified hydraulic loading-phosphorus runoff relationships critical for the BMP. At the watershed level, SCS used the monitoring data to test and calibrate its Vermont Phosphorus Models; these models are used for water quality planning in Vermont.

State Water Quality Planning

During the late 1970s, state water quality management agencies were engaged in section 208 areawide nonpoint source management planning as a result of the 1977 Clean Water Amendments. SCS and Conservation Districts participated in a task force convened by the Vermont Department of Natural Resources (now Vermont Department of Environmental Conservation) that examined agricultural watersheds throughout the state. The task force subjectively ranked eight of these as highest priority for agricultural nonpoint source treatment programs. This ranking was included in the state's first State Water Quality Plan for Controlling Agricultural Pollution.

As nonpoint source planning and treatment activities increased in the early 1980s, SCS (in cooperation with other USDA agencies and at the request of the Vermont Department of Environmental Conservation) conducted the Agricultural Runoff in Selected Vermont Watersheds Cooperative River Basin Study (USDA, 1983). The study inventoried sample farms, estimated runoff, and formulated management options for 19 of Vermont's agricultural watersheds. The Vermont

Department of Environmental Conservation used the results to revise Vermont's Water Quality Plan by supplementing the official priority list of agricultural watersheds for project assistance. This priority list is now included in the state's Clean Water Strategy (VT A.N.R., 1988).

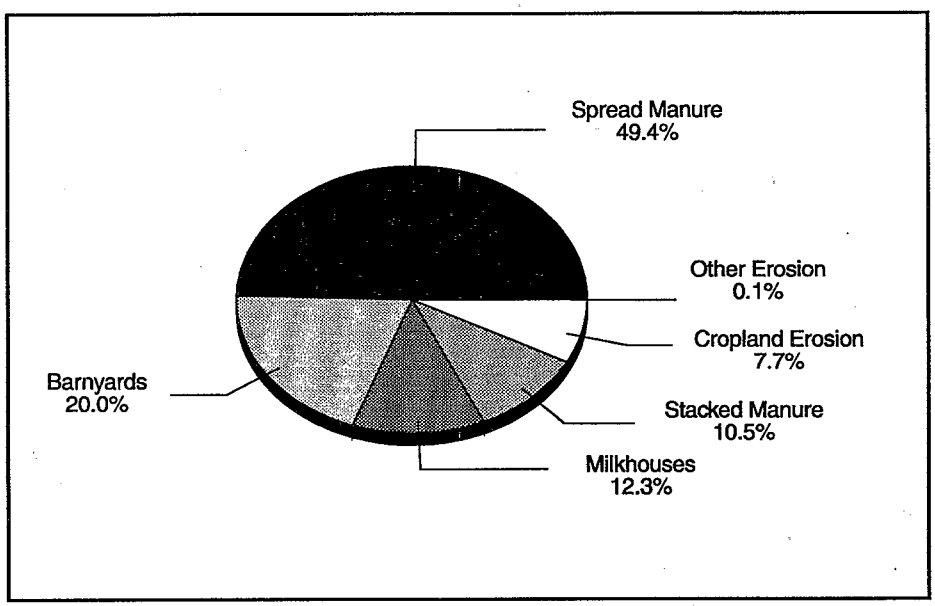

Figure 2. St. Albans Bay watershed: agricultural sources of treatable phosphorus, pre-project.

Vermont Phosphorus Models as Watershed Management Tools

Another major product of the planning and monitoring activities has been the development and use of personal computer models to process farm data for estimating annual phosphorus loads by source category on each farm. These values can be aggregated as estimates of phosphorus loads at the watershed outlet. Planners can use contemporary eutrophication models to process these watershed load estimates for evaluating the impact of various agricultural nonpoint source management scenarios. Managers can also use model outputs to target treatment for various sources of nonpoint phosphorus in the watershed. For example, the model outputs, as depicted in Figure 2, show that in the St. Albans Bay Watershed manure spreading was a principal, treatable phosphorus source while cropland erosion was least significant.

The model output is also extremely helpful to rank farms in a watershed for treatment assistance. Farms can be arrayed by descending order of phosphorus load as a priority list for participation. This output can also be used as a tracking mechanism to account for achieving watershed goals for phosphorus reduction.

Watershed Progress

Vermont has made significant progress in managing nonpoint source runoff in priority watersheds (Figure 3). SCS has completed the LaPlatte River Watershed under the Watershed Program, P.L. 83-566, and has seven other P.L. 83-566 watershed projects in progress. This program also provides technical assistance for planning of other natural resource projects implemented under other authorities. For example, the Lower Missisquoi River Hydrologic Unit Project has been funded under USDA's joint agency water quality initiatives. ASCS has funded three special water quality watershed projects with technical assistance from SCS. To date, these 11 watershed projects have treated agricultural runoff from 460 dairy farms. The treatment is reducing phosphorus loads to streams by an estimated 70,000 pounds annually.

Another major development for water quality protection of Lake Champlain on a watershed basis has been the passage of the Lake Champlain Special Designation Act of 1990 (Act). The Act provides for widespread involvement in the development of a comprehensive pollution prevention, control and restoration plan for the lake. This involvement includes the States of New York and Vermont, EPA, USDA, the U.S. Department of the Interior, other federal agencies, citizens, and local government officials .

The Act also designates the entire Lake Champlain Basin as a USDA Special Project area under the Agricultural Conservation Program. The Act directs the Secretary of Agriculture to develop a comprehensive agricultural monitoring and evaluation network for all major watersheds in the Lake Champlain Basin. An appointed strategic core group has prepared a technical report

(LCMC, 1993) with partial funding through EPA. This report lays out a strategy for providing answers to the vexing questions and issues surrounding agricultural nonpoint source pollution. Part of this strategy is already being implemented as studies are underway to fill knowledge gaps about phosphorus runoff behavior in the farm field—from the field to the stream and the instream processes that govern phosphorus transport to the watershed outlet. The result will be more effective and efficient phosphorus management techniques in the watersheds.

Conclusion

Vermont has found its watershed approach very effective in addressing the state's agricultural runoff problems. State agencies and the conservation districts have, from the beginning, assessed agricultural runoff problems and developed the state's agricultural pollution control plans based on watershed units. This approach has provided for close coordination and cooperation among the various agencies, entities, organizations, and citizens.

Watershed management tools now available or under development will greatly facilitate agricultural nonpoint source program efforts as Vermont farmers, the Vermont Departments of Agriculture and Environmental Conservation, SCS, and its partners forge ahead in protecting water quality within the watersheds.

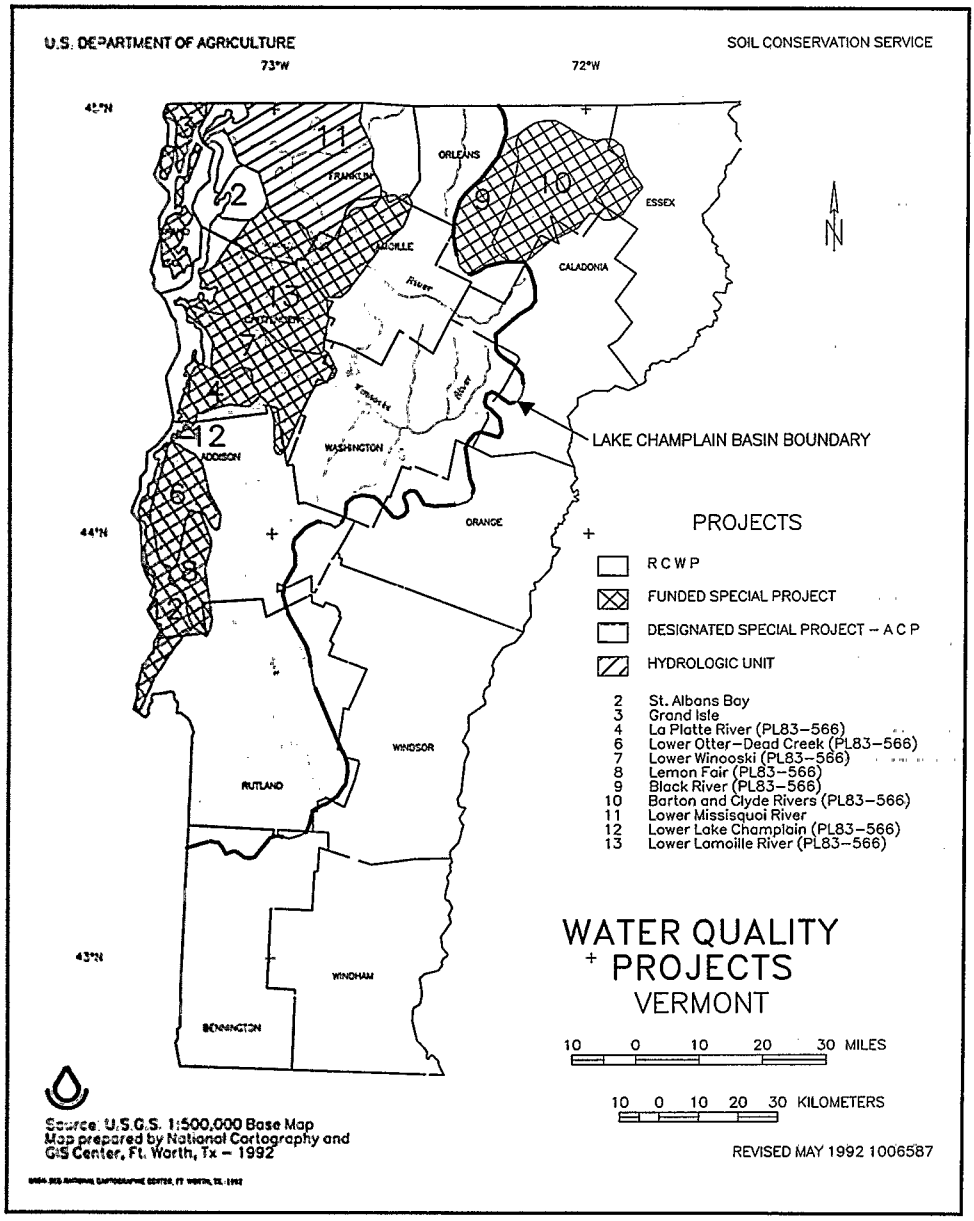

Figure 3. Agricultural NPS watershed projects.

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Watershed Assessment in the Albemarle-Pamlico Region

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Background

The Albemarle-Pamlico (A/P) estuary and its catchment encompass over 23,000 square miles of land and water area in North Carolina and Virginia, making the system the second-largest estuarine complex in the United States. There are about 2 million permanent residents in this area, with several of its prominent population centers experiencing rapid growth. A vast majority of the land, however, is rural with forested land (4.7 million acres), agricultural land (4.4 million acres), and wetlands (2.2 million acres) dominating the landscape (Albemarle-Pamlico Estuarine Study, 1992).

In 1991, Research Triangle Institute (RTI) was contracted by the A/P Estuarine Study (one of 17 National Estuary Program sites designated by the U. S. Environmental Protection Agency (EPA) in 1986) to estimate nutrient budgets and analyze historical toxicant data. With a focus on using the A/P data base to support areawide watershed assessment, the effort was broadened to include a general study of environmental conditions in 1992. RTI has also developed a watershed model to support a pollutant trading initiative in the Tar-Pamlico River basin, one of the tributaries of the Pamlico Sound.

In the course of this work, several general principles have surfaced that could have broad utility for regional-scale watershed assessment projects. We have learned that it is important to:

- *Devote energy early on to delineating watershed boundaries.* Seek consensus on boundary location. Build information systems and models based on these units.
- *Invest in a geographic information system (GIS).* But make sure that your GIS is integrated with other platforms and tools so that your information remains accessible to the non-GIS community.
- *Develop data bases and use assessment tools which recognize spatial and temporal limitations.* For example, it is always possible to spatially aggregate from smaller to larger spatial units, but can be problematic to disaggregate from larger to smaller units.
- *Complete retrospective analyses.* The results of retrospective analyses are valuable in their own right but can be especially useful for strategic planning purposes. The toxics analysis we conducted for the A/P Study Area has stimulated considerable interest in reassessing toxicant monitoring, assessment, and management programs.
- *Recognize watersheds as landscapes.* Study critical areas within the landscape such as riparian corridors.

Watershed Delineation and PC Watershed Data Base

In 1991, RTI, the North Carolina Center for Geographic Information and Analysis, and the North Carolina Division of Environmental Management (DEM) completed a watershed delineation project in the North Carolina portion of the A/P Study area (Dodd et al., 1992). We delineated watershed boundaries based on three factors. First, all boundaries were made to be consistent with U.S. Geological Survey (USGS) cataloging units (CUs). Second, DEM sub-basin boundaries were adjusted to nest within CUs. Third, watersheds were identified so that outlets coincided with the locations of gaging stations with continuous flow recorders and good water quality records. This scheme resulted in identification of 68 polygons in the North Carolina portion of the A/P study area (Figure 1). The Soil Conservation Service is currently delineating additional small watersheds which will be nested within these sub-basins, resulting in an integrated, interagency classification scheme.

We used the sub-basin boundaries as the basis for developing a watershed-oriented data base of information related to point and nonpoint sources (Tippett and Dodd, 1993). To develop the data base, we had to convert much of the data related to nonpoint sources from a county orientation to a watershed orientation. Data elements are summarized in Table 1. The data base was developed with FoxPro Version 2.0 and runs on IBM-compatible personal computers.

We also prepared sub-basin "profiles." The profiles included a series of maps and a ranking of a number of indicators of resources, stressors, and impairment for each sub-basin (Table 2) (Dodd et al., 1993a). Nutrient budget and toxics analysis projects that provided the foundation for profile development are discussed below.

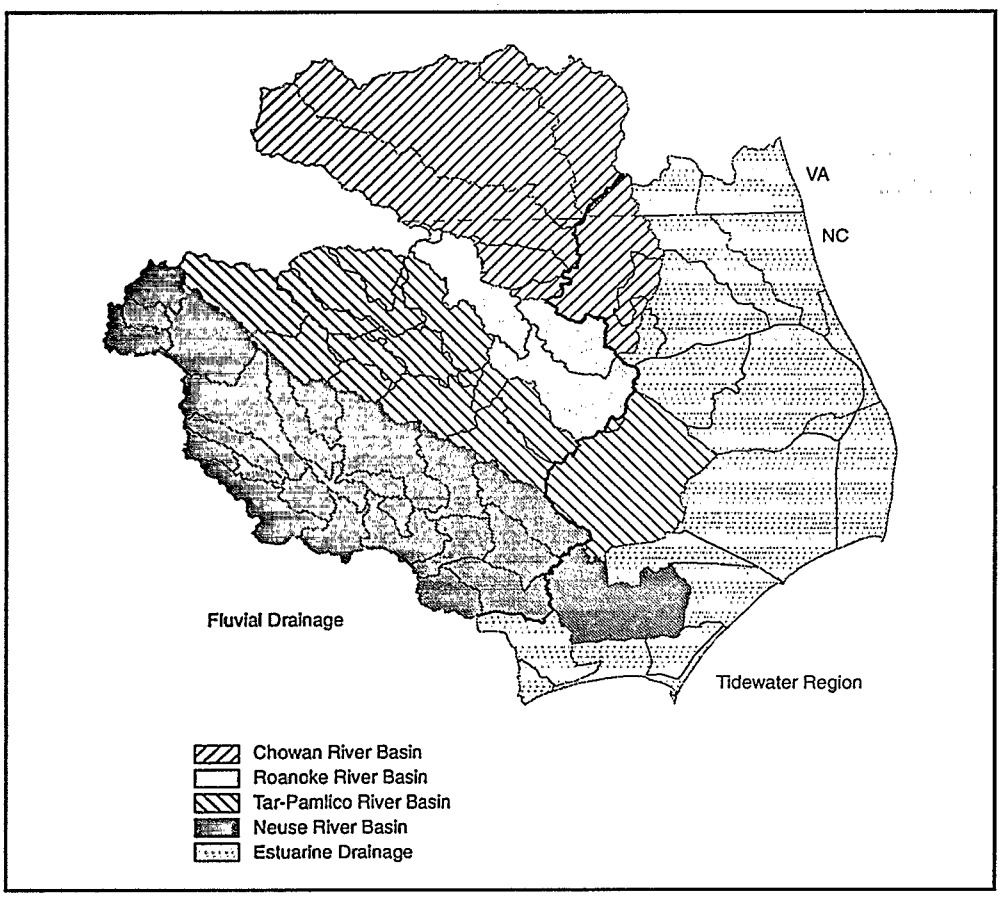

Figure 1. Basins and sub-basins in the study area.

Areawide Nutrient Budgets

In one A/P Study Area project, we estimated annual average total nitrogen and total phosphorus inputs to surface waters for each sub-basin (Dodd et al., 1992). Runoff from various land cover categories, direct input of atmospheric nutrients to surface waters, and point sources were considered. The data sources we used were representative of the mid to late 1980s.

We chose pollutant loading factors ("export coefficients") based on a literature review (Table 3) and multiplied them by the area in several land use/land cover categories (as determined from LANDSAT images) to estimate runoff inputs and atmospheric inputs. Output from EPA's Regional Atmospheric Deposition Model

(RADM) was also used to estimate atmospheric nitrogen inputs. We did not explicitly account for other sources of nutrients, such as septic tanks, local atmospheric sources, unmonitored point sources, and concentrated animal operations. We did not consider transport of nutrients from the source to the estuary; thus estimates should be considered as potential loadings to the estuary and sound systems. Estimates were calculated for total nutrient loading, with the exception of atmospheric nitrogen estimates from the RADM model which were available for specific nitrogen species only.

We estimated that a total of more than 43 million kilograms/year (kg/yr) of nitrogen and more than 4 million kg/yr of phosphorus enter surface waters by discharge from point sources, runoff, direct atmospheric deposition, and discharge from upstream reservoirs (Figure 2). Agriculture is the largest nonpoint source category for both phosphorus and nitrogen inputs. We also calculated area loading rates (Figure 3) to compare sub-basin loadings per unit area.

The export coefficient model allows for a very general assessment of nutrient loading, and therefore has limited applicability for studying issues such as the effectiveness of management measures or the transport of nutrients through a watershed. To enhance modeling capabilities, we currently developed mass balance and loading function and mass balance models (RTI, 1994).

The Generalized Watershed Loading Function model application provides an "engineering compromise between export coefficients and chemical simulation models" (Haith et al., 1992). The mass balance model describes nutrient cycling with nutrient input estimates for fertilizer, manure, biological fixation, nutrient output estimates for crop harvest, and calculation of a residual term.

Land Use Analysis Using GIS Buffering

In an effort to focus efforts on riparian management issues, we completed a GIS hydrologic buffering analysis (Dodd et al., 1993b). The analysis involved identifying surface water features, creating buffers, overlaying the buffers on LANDSAT-derived land use/land cover (LU/LC) data, and summarizing and analyzing the results.

The analysis indicates that approximately 75 percent of land within 100 feet of streams is forest or wetland. The percentage of streamside land in forest/wetland varies from 89 percent in the Fishing Creek watershed to only 40 percent in the Tranters Creek watershed. Riparian corridors have a higher percentage of undeveloped land in the upper basin than in the lower basin, probably because of factors related to suitability for agriculture and urban development (Figure 4). Within a given watershed,

Table 1. PC sub-basin database elements

Data Type	Data Source
Point Source Loadings	NCDEM Discharger Monitoring Records
Land Use/Land Cover	LANDSAT
Agricultural Land Use	Federal Agricultural Census
Livestock Inventories	State Agricultural Statistics
Conservation Technology Implementation	USDA Conservation Technology Information Center
Human Populations and Projections	NC Office of State Planning
Nutrient Budgets	Dodd et al., 1992

Table 2. Indicators included in sub-basin profiles

Indicator Category	Indicator Type	Data Layer
Critical Resources Areas	Estuarine Fisheries	Shellfish, Crustacean, Finfish Harvest
	Aquatic Habitat	Nursery Areas, SAV, Outstanding Resource
	Palustrine/Terrestrial Habitat	Waters; Freshwater Mussel Habitat Wetlands; Natural Areas
Use Impairment	Toxicant Contamination	Point Source, Ambient Water, Sediment, Fish and Shellfish Exceedances, Fish Consumption Advisories
	Eutrophic Waters	Algal Blooms
Stressors	Waste Sites	Landfills, Superfund Sites, Hazardous Waste Sites
	Nonpoint Sources	Marinas, Agricultural and Urban Land, Nonpoint Source Nutrient Loading
	Point Sources	Nutrient Loading, Toxicant Loading

SAV = Submerged aquatic vegetation.

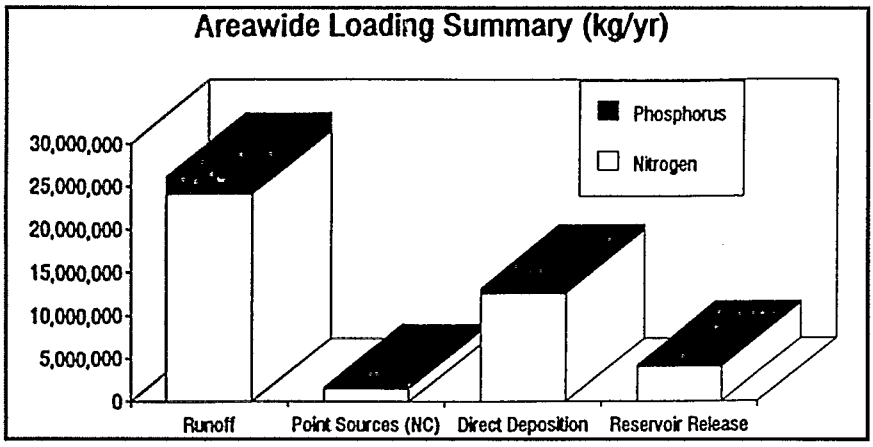

Figure 2. Nutrient budget summary.

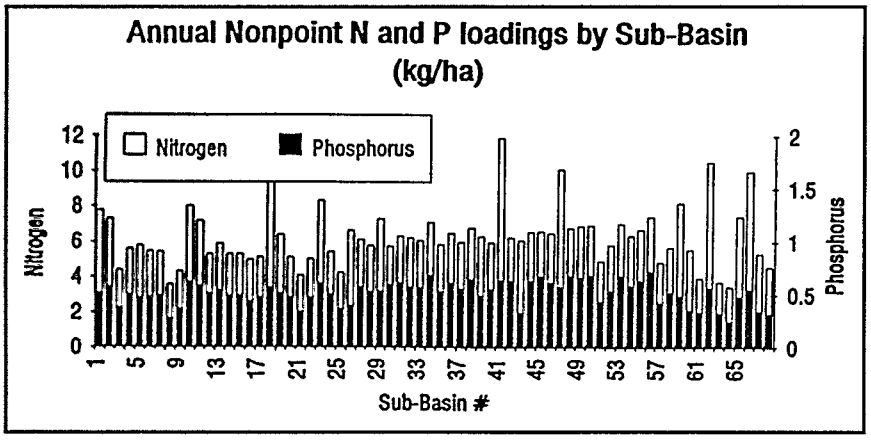

Figure 3. Sub-basin nutrient loading.

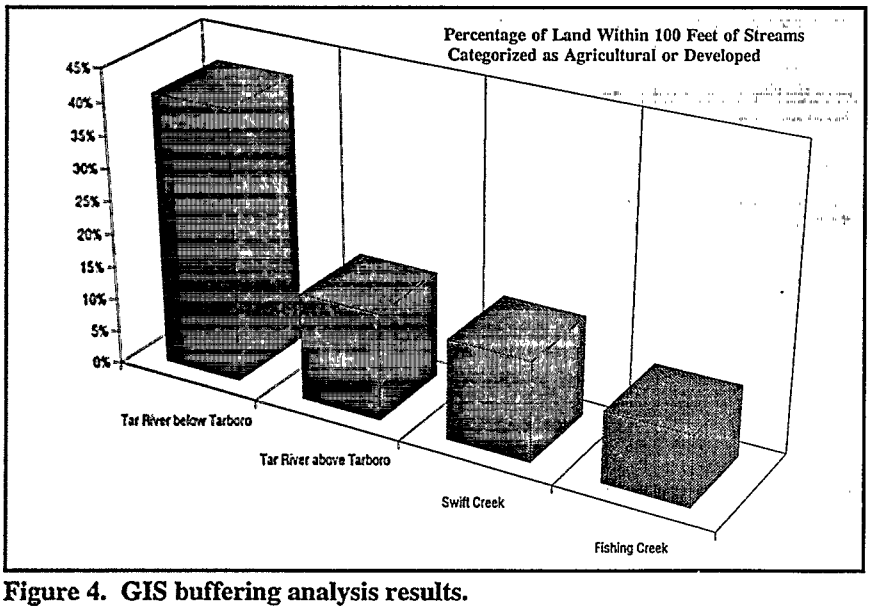

Figure 4. GIS buffering analysis results.

long corridors can have little or no riparian buffer.

It is also important to point out that the amount of the watershed within the 100-foot buffer is only about 5 percent of the total watershed area. One implication is that nonpoint source control programs should be able to more readily geographically focus their efforts in these areas than in large landscapes like river basins or counties.

Comparison of results for different sub-basins can provide useful input into the prioritization of watersheds for ecological restoration efforts and associated nonpoint source control benefits. This analysis also allows for identification of individual stream reaches within a watershed where insufficient riparian buffering may warrant special attention. A final potential use might be in periodic studies of changes in environmental quality within riparian corridors. The net effect of wetlands conservation efforts, urban development, and changes in agricultural practices are possible topics of interest. This effort would require periodic updates of key data (e.g., land use/land cover).

Toxics Analysis

Monitoring of toxicants in effluents and in the environment began in the 1980s. However, no systematic evaluation of the data collected had been attempted prior to 1991. In that year, RTI undertook a project to (1) analyze toxics information from diverse agencies and data bases in a consistent manner; (2) estimate annual toxics loadings from point sources and predict the potential for exceedances of water quality standards due to these sources; and (3) compare ambient water column, sediment, and fish tissue data to the most appropriate standards or criteria available (Cunningham et al., 1992). For those toxicants for which the state had not defined standards, we used EPA criteria, action levels, or other levels of concern as screening

values (Table 4). This study was limited to the North Carolina portion of the A/P Study Area. Based on DEM's recommendations, we focused on metal contamination issues, although organic contaminants were evaluated in fish and shellfish tissue as well.

Three metals (mercury, arsenic, and lead) and dioxin were the four pollutants most frequently detected in whole fish at concentrations exceeding the selected levels of concern for wildlife. Dioxin and mercury were the two toxic pollutants most frequently detected in fish tissues at concentrations exceeding the selected human health safety values. The primary sources of dioxin in the A/P Study Area are presumed to be several large pulp and paper mills. Metal loadings from point sources and nonpoint sources such as urban runoff, leachate from landfills, resource extraction activities, or atmospheric deposition may all contribute to metal contamination of the system.

Table 4. Summary of toxics screening analysis

Parameter	Data Source	Screening Method	# of Facilities/ Sites Exceeding Screening Criteria	Pollutants Exceeding Screening Criteria
Point sources	Discharger monitoring reports	Dilution model (7Q10 and average flow)	7Q10 flow: 21 Average flow: 12	Al, As, Cd, Cr, Cu, Pb, Hg, Ni, Se, Ag, Zn, CN
Ambient water quality	STORET	NC water quality standards	Freshwater: 24 Estuarine: 6	Al, Cu, Pb, Hg, Ni, Zn
		EPA aquatic life criteria (criterion continuous concentration)		
		NC or EPA human health criteria		
Sediment quality - Freshwater	STORET	EPA threshold concentrations USEPA, 1985)	0 (only 3 stations sampled)	None
Sediment quality - Estuarine	Riggs et al., 1989, 1992, and 1993 (draft)	NOAA low effects range (ER-L) and median effects range (ER-M) (Long and Morgan, 1990)	256 (ER-L)	ER-L: Pb, Hg, Zn, Cu, Ni, Cr, Cd, As, Ag
			51 (ER-M)	ER-M: Pb, Zn, Cd, Hg, Cr, Ni, Cu
Fish tissue contamination - Wildlife (whole fish)	NCDEM	Metals: USFWS (Schmitt and Brumbaugh, 1990)	73 (metals)	Cu, Pb, Hg, Cd, As, Zn, Dioxin
		Organics: Scientific literature	13 (dioxin)	
Fish tissue contamination - Human health (fish fillet and shellfish)	NCDEM	EPA risk-based screening values (USEPA, 1992)	42 (fish)	Hg, As, Pb, Cu, DDT, and Dieldrin
			18 (shellfish)	As, Zn, Pb
			39 (fish)	Dioxin

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Monitoring Long-Term Watershed/ Ecosystem Change for Preserved Lands

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Background

Watershed conditions are affected by uncertain and complex interactive environmental trends, many of global occurrence. Questions regarding watershed science, although often site specific thus require answers on a global basis. Frequently, input to the highest levels of government decision-making is needed if modern society is to mitigate, stop and/or reverse the large-scale watershed/ ecosystem alterations now occurring world-wide. However, our ability to sensibly and effectively manage natural resources in today's global environment is often constrained by our lack of knowledge about the hydrologic cycle and its relationship to the geosphere and the biosphere. We know the current condition of park natural resources and those of other preserved lands are subject to many widespread anthropo-genically induced changes resulting from acidification, eutrophication, toxic substances, boundary encroachments, over use, species shifts or extirpation, desertification, loss of biodiversity, land use change, and sea level rise. The watershed approach to long-term research and monitoring of natural and remote areas within National parks and similar reserves provides important data on ecosystem processes and interactions for detecting both spatial and temporal change in environmental conditions. These data collections allow the partitioning of cause and effect relationships of ecological change within watersheds. They also serve to meet both reference and early warning objectives correlative to natural ecosystems change. Accordingly, the scientific and public policy communities can employ watershed/ecosystem information as one means of obtaining early indication of the potential effects of anthropogenically induced stress and a much better assessment of its magnitude (Herrmann, 1982, 1990; Herrmann et al., 1993). Use of the concept to address a number of *acid precipitation* or biogeochemical cycling research goals has demonstrated the utility of these integrated watershed data for inter-ecosystem comparison between preserved and other watersheds (Herrmann and Stottlemyer, 1991).

The need for watershed research studies in parks or equivalent reserves, where mandates minimize direct anthropogenic change, is fundamentally critical to our understanding of major natural resource issues. Because National Park Service (NPS) resources management information demands are often similar to data requirements of other national and international programs, many linkages have influenced our conceptual approach. A few examples of comparable activities are the United Nations Educational, Scientific and Cultural Organization (UNESCO) and U.S. Man and the Biosphere Program (Franklin and Krugman, 1979; Wiersma et al., 1979), the Long Term Ecological Research Program of the National Science Foundation (NSF, 1979), the interagency National Acid Precipitation Assessment Program (NAPAP, 1981), the intergovernmental US/USSR (now US/Russia) Environmental Bilateral, Biosphere Reserves Project (Franklin et al., 1984; Wiersma et

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al., 1984; Herrmann et al., 1993), the U.S. Committee on Earth and Environmental Sciences (U.S. Committee on Earth Sciences, 1992), and the International Geosphere-Biosphere Programme (ICSU, 1986). Concurrently, our program is linked cooperatively where possible with initiatives in other agencies and other institutions at both the national and international levels (Table 1). The watershed research program of the NPS is currently unique, however, in addressing the needs of and issues important to the present and future management of public lands that are set aside to be preserved largely in a natural state.

The NPS program of long-term watershed/ecosystem research officially began with proposals in 1980 to monitor atmospheric inputs and to establish integrated baseline data on climate, chemistry, geology, soils, vegetation, hydrology, and aquatic resources. Our intent at the time was to relate atmospheric inputs to acidification, ecosystem response and stream chemistry outputs. Quantification of the hydrologic cycle and chemical flux were major objectives of the watershed monitoring and research programs. Building an information base sufficient to test a number of hypotheses regarding acidification and change at the watershed/ecosystem level was emphasized through the first 10-year term of the program. Study sites were selected to be biogeographically representative of naturally functioning ecosystems in relatively remote areas. Five sites are active today as a result of the program. Four were established as part of the NAPAP: Rocky Mountain National Park, Sequoia and Kings Canyon National Parks, Olympic National Park and Isle Royal National Park. The fifth site, Shenandoah National Park, includes numerous related research and monitoring efforts. In addition, early work that included effects of acid precipitation, was performed at a sixth site, Great Smoky Mountains National Park. Given this experience the NPS Watershed Research Program has retained a mass balance concept and the Biosphere Reserve *core* area concept for natural lands surrounded by developed lands against which resource's change can be assessed.

Table 1. Current integrated programs related to the NBS/NPS watershed research program that encompass assessment of a broad range of environmental impacts

Program	Lead Organization
Watershed Program	U.S. Environmental Protection Agency (EPA)
Environmental Monitoring and Assessment Program (EMAP)	U.S. Environmental Protection Agency
Temporally Integrated Monitoring of Ecosystems (TIME)	U.S. Environmental Protection Agency
International Geosphere Biosphere Program (IGBP)	International Council of Scientific Unions (ICSU) Scientific Committee on Problems of the Environment (SCOPE)
U.S. Global Climate Change Program	U.S. Interagency Committee on Earth and Environmental Sciences (CEES)
Water Energy and Biogeochemical Budgets (WEBB)	U.S. Geological Survey (USGS)
Hydrologic Benchmark Network	U.S. Geological Survey
National Stream Quality Accounting Network (NASQAN)	U.S. Geological Survey
Interagency Fresh Water Imperative (FWI)	National Science Foundation
Precipitation Measurement Program	World Meteorological Organization (WMO)
National Atmospheric Deposition Program (NADP)	Agricultural Research Service/USGS
Global Environmental Monitoring System (GEMS)	United Nations/United Nations Environment Programme (UNEP)
U.S. Long-Term Ecological Research Program	National Science Foundation
Forest Health Program	U.S. Forest Service
Watershed Research	U.S. Forest Service
Man and the Biosphere Program (MAB)	United Nations Educational, Scientific and Cultural Organization (UNESCO)

Program Objectives

Watershed studies in the 1990s provide the context for focusing information about watershed conditions toward assessment of ecosystem changes and of possible impacts of global climate change. Meteorologic, microclimatic, and hydrologic data available now and being collected on selected watersheds are being utilized in conjunction with data from ecosystem process studies, from the same watersheds to determine whether the predicted climate driven responses are occurring or are likely to occur. As an example, at Isle Royale National Park these data now make it possible to test hypotheses regarding the role of nitrogen in conifer forests (Stottlemyer, 1993). New data from Noatak are being used to evaluate the nitrogen cycle at the spruce-tundra ecotone (Binkley et al., 1992) and for questioning existing scientific paradigms. Thus, park researchers and resources managers alike are provided needed information for dealing with today's complex local, regional, and global natural resources issues, and against which present and future resources management actions may be assessed.

For the period 1982-1989, the National Park Service Watershed Research Program, as previously discussed, was designed primarily to provide information to detect actual and potential impacts from changing atmospheric chemistry. Most importantly, early objectives emphasized building an information base and core data sets sufficient to test a number of hypotheses regarding acidification or biogeochemical change in representative watersheds (Table 2). The original and still pertinent program objectives were:

- Detection of chemical and biological change within each represented ecosystem.
- Partitioning cause-and-effect relationships in long-term ecosystem change.
- Evaluation of how different unmanipulated natural sites will respond to acidification.
- Establishment of an early warning system for measuring ecosystem response.

For the period 1990-2000, the program will provide for the broad characterization of watersheds within representative units of the NPS in order to develop enhanced understanding of relationships between watershed processes and ecosystem status. Sites continue to have a number of essential common attributes (Table 3). These site requirements apply not only to NPS study watersheds, but equally as well to most U.S. Biosphere Reserve sites, and are also suggested as appropriate for potential global base-line sites. Contained within this broad design is a major focus on interpreting watershed information as an early indicator of potential impairment to natural resources. The current study objectives are:

1. Develop and implement example procedures and protocols to identify, collect, organize, analyze, and synthesize selected watershed data within representative watersheds and to interpret for park management the current status and trends in the condition of the park natural resources contained therein.
2. Establish baseline conditions for watershed processes against which

Table 2. Summary of core data collection for NPS watershed studies

Domain	Data Field
Precipitation (chemistry)	Deposition Wet Snow Dry Bulk collections
Climate	Windspeed and direction, humidity (or equivalent), temperature, incident solar radiation, precipitation amount
Vegetation	Permanent plots
Soils	Plots in a manner consistent with vegetation analysis and specific samples relating to water chemistry flux samples
Hydrology and aquatic studies	Temperature, chemistry (major cations and anions), stream discharge Lake stage (inflow-outflow as needed for mass balance) Ground water mass balance (inputs/outputs) Ground water (chemistry characterization) Characterize aquatic system and establish baseline of indicator species
Paleolimnology	Sediment cores (diatom and heavy metals analysis) Pollen analysis, if possible
Pollutants	Trace elements (metals) in soil, in litter, in vegetation, in water

Table 3. Commonalities that apply when trying to develop or to characterize watershed sites within a monitoring and research network

- Has long-term protected status (site integrity)
- Has a core area (an undisturbed watershed)
- Has basic inventory information
- Has a research and/or monitoring capability
- Has established monitoring or is willing to establish techniques that will not change unless they can be calibrated to a new technique
- Has or is willing to establish a sampling protocol that fits within the time frame of known physical and biologic events
- Has or is willing to establish standardized data collection, sample storage, sample archival, and data management schemes
- Has or is willing to establish data collection techniques that can be accurately repeated.
- Identifies questions or hypotheses that are relevant
- Identifies anticipated changes and where they are expected to occur
- Identifies an experimental design to allow for detection of change and understanding the mechanisms of change
- Locates sites along probable dispersal gradients or existing pollution gradients
- Locates sites to cover major identifiable environmental variations and ecoregions

change in the hydrologic cycle can be evaluated.

3. Establish watershed response to stress and report on its significance to the managers of park/reserve resources.
4. Develop watershed sites as part of a national and possibly international system of background sites establishing a climatic, hydrological, ecological, and biogeochemical baseline against which national and global trends can be measured.
5. Develop and test a watershed research theme to be implemented within the context of NPS Global Climate Change and Inventory and Monitoring.
6. Develop strong linkages between the NPS Global Climate, Inventory and Monitoring and Watershed Research Programs.
7. Coordinate with similar interagency, inter-institutional, and international efforts.

At each research site, while meeting these broad objectives, activities contribute to the accumulation of applicable baseline information on deposition chemistry, climate, hydrology and ecosystem processes. Systematic sampling provides chemical information about trace elements, sulfate and nitrate in air, water, soil, vegetation, and forest litter. These measurements must still be combined with other data sets, including biology, geology, hydrology, land-use, topography, historic and pre-historic records, to better understand ecosystem-level processes, or to test hypotheses regarding prominent global issues (Herrmann, 1982).

Present Status

At the close of 1992, 10 NPS areas, representing as many biomes, have begun some watershed research activities: Crater Lake National Park, Denali National Park and Preserve, Glacier National Park, Great Smoky Mountains National Park, Isle Royale National Park, Noatak National Preserve, Olympic National Park, Rocky Mountain National Park, Sequoia National Park and Shenandoah National Park. Six sites have been designated as part of the NPS Global Climate Change (GCC) Program: Rocky Mountain, Isle Royale, Olympic, Sequoia, Glacier, and the substantial lake studies program at Crater Lake. Three sites are now included in the NPS Inventory and Monitoring (I&M) Program: Shenandoah, Great Smoky Mountains and Denali. New potential watershed sites included in the NPS GCC Program are Everglades National Park, Organ Pipe Cactus National Monument, Buffalo Wild and Scenic River, and Ozark National River.

Information presently collected at these sites is leading to a methodical description and quantification of the watersheds. Our continued progress in finding solutions to many complex ecological and environmental problems relies on our maintaining interdisciplinary efforts to understand linkages among climate, the hydrologic cycle, chemical processes and the biota. Herrmann and Stottlemyer (1991) discuss successful applications of these data to assess fundamental biogeochemical cycles (e.g., carbon, nitrogen, sulfur). We should note that understanding these cycles relates directly to our ability to answer questions not only about water availability and quality, but

also on changes in plant and animal distribution, abundance and biodiversity, and fire regimes, to mention but a few issues that can alter watershed processes.

Some site-specific results important to watershed science and to management of park resources follow. Sequoia National Park study sites include alpine and sub-alpine watersheds with low buffering capacities within two distinct physiographic regions. Atmospheric inputs at three elevations representing three major ecosystems (chaparral, coniferous forests, and sub-alpine) have been monitored, and baseline data on soils, vegetation, and aquatic communities collected. Studies include analysis of precipitation chemistry, dry deposition, stream hydrology, aquatic chemistry and biology, soil chemistry, meteorology, nutrient flux, and vegetation structure and function. Emphasis has been placed on detection of long-term change of atmospheric inputs and their effects on natural ecosystems, across the elevational gradient. Temporary acidification of high-elevation lakes and streams of the Sierra Nevada has been documented during spring snowmelt and after acidic summer storms. The effects of atmospheric contaminants on forest productivity continue to be evaluated. Results for the past decade do not show a critical or changing situation with regard to atmospheric pollutant contributions to precipitation or surface water. Plans exist to use watersheds as sampling units for a broad array of long-term atmospheric, terrestrial, and aquatic monitoring. An extensive program of water quality and aquatic ecosystem monitoring has been proposed to augment the program. The past 5 years have dramatically revealed the importance of park waters not only to the park ecosystems, but also to the State of California. Future plans will integrate the watershed program with ongoing global change research in the Sierran biogeographic region emphasizing park ecosystems (Parsons and Graber, 1985; Tonnesson, 1991; Everson and Graber, 1992).

Rocky Mountain National Park activities have focused on atmospheric inputs to alpine and sub-alpine lakes of low buffering capacity. Baseline data on soils, vegetation, and aquatic communities have been collected. Studies have included soil and water chemistry, and have investigated historical changes in acidity in Rocky Mountain high elevation lakes. No permanent influence attributable to acid deposition has been observed. In the Loch Vale sub-alpine long-term watershed study site, 7 years of biogeochemical study has greatly expanded our knowledge of the response of natural systems to stress, sources and types of both wet and dry deposition, bedrock weathering rates and weathering mechanisms, soil characteristics and buffering mechanisms, terrestrial nutrient cycles, alpine and sub-alpine surface water chemistry, and biology and hydrology. We observe large differences in precipitation amount and ionic concentrations between the Loch Vale site and a nearby site, Beaver Meadows, about 15 km northeast and 672 m lower in elevation. Loch Vale is less likely to be influenced by anthropogenic inputs from the Front Range urban area. Loch Vale soils have a limited ability to buffer increased amounts of acidity from deposition, and the influence of soil processes on surface water composition is restricted to a short period at the beginning of snowmelt. An important finding is the major source of acid-neutralizing capacity appears to come from microcalcite veins in the igneous bedrock, which are weathering through physical (freeze-thaw) breakdown of primary minerals. Thus, surface water chemistry directly reflects the hydrology. Concentrations of major anions and cations increase as flow decreases through the winter, and decrease as snowmelt continues after an early flush of materials from the soil solution. Extrapolations and inter-site comparisons are now being considered to other alpine and sub-alpine study sites within the Rocky Mountain region. Loch Vale is now a global change biogeographic region study site (Baron and Bricker, 1987; Denning et al., 1988; Baron, 1992; Baron et al., 1992).

Isle Royale National Park was originally chosen to represent an upper Midwest forest ecosystem experiencing increased levels of acid deposition. Seasonal variations in precipitation chemistry have been evaluated as to their effect on small watershed ecosystems. Other investigations include quantification of the increase in atmospheric loading with elevation above Lake Superior, how vegetation affects the quality and quantity of precipitation, the influence of alkaline glacial till on streamwater quality, the quantification of biogeochemical cycling of specific nutrients, and snowpack quality.

Important understanding of watershed nutrient cycles has been obtained. Sulfate was found to be minimally adsorbed by soils, suggesting that nutrient leaching is possible in many similar forest systems due to sulfate mobility. This process could accelerate ecosystem acidification. Preliminary data also show an increase in forest ecosystem nutrient leaching attributable to sulfate in acid deposition. Soils throughout the region were not generally derived on site, but were developed from limestone materials derived to the north and east by glacial activity. This has resulted in soils that are more alkaline than indicated by either the bedrock or vegetation. Inputs of atmospheric sulfur are on the decline at watershed research sites, an observation consistent with some regional studies of stream chemistry. However, this decrease is not statistically significant. Input/output budgets and nutrient cycling studies in all major forest types show these ecosystems are currently saturated with sulfate. The excess sulfate results in anion leaching of base cations from the forest rooting zone. However, the amount leached is still very small relative to the total soil reservoir of exchangeable base cations. In contrast to sulfur, the concentration of nitrogen species in precipitation is increasing. Computations of nitrogen inputs show that the combined inputs of wet and dry deposition exceed ecosystem requirements. Over 50 percent of this input is in the form of ammonium, which may favor conifer species. In the future, excess nitrate could contribute to anion leaching of base cations from these ecosystems. Intensive multiyear studies of the fate of N species have not provided evidence that much of it is getting below the rooting zone. Thus, the forest community appears to be utilizing this excess nitrogen. Future effects of continued increased nitrogen inputs could be nitrate leaching of cations particularly in conifer forests, nitrogen toxicity to some forest species, and changes in species composition due to a nitrogen fertilizer effect. Isle Royale has been designated a biogeographic regional global climate change research site, thus becoming an important site for understanding the value of nitrogen response during variable climate conditions (Stottlemyer and Hanson, 1989; Stottlemyer et al., 1992).

Olympic National Park represents a relatively pollution free area with substantial maritime influence on terrestrial and aquatic ecosystems. Pronounced differences in the dominant ions in precipitation (sodium and chloride) and streamflow (calcium and sulfate) occur. The research objectives are to develop an understanding of the sources and flux of coastal sulfur, and the biologic implications. The functioning of old-growth forest watersheds in the western Olympics is now better understood. Streams in these watersheds are well buffered and will not be significantly impacted by acidic atmospheric inputs; however, the vegetation strongly modifies precipitation chemistry, and acidifies precipitation inputs. The West Twin Creek watershed has been identified as potentially an excellent site to monitor impacts of changing global climate on watershed processes at the marine/terrestrial interface. Olympic is now a designated biogeographic regional global climate change research site currently emphasizing the alpine sub-alpine ecotone. West Twin Creek is linked as a potential control site to the Olympic Peninsula Research Center (Thomas et al., 1989; Edmonds et al., 1992).

Shenandoah National Park, along the crest of the Blue Ridge Mountains, is representative of an eastern site with very high sulfate deposition. Studies now monitor and characterize stream and soil sensitivity to airborne pollution. Baseline data has been collected to determine acid induced change. Research has concentrated on analysis of watershed chemical budgets. Poorly buffered streams have been chronically acidified in the park and surrounding region and are currently being monitored. Information from watershed monitoring and research has been used in formation of the regional air quality debate (Ryan et al., 1989; Webb et al., 1989).

Crater Lake National Park is a unique resource with an extensive data set on lake and watershed processes collected over the past 10 years. These data have greatly increased an understanding of one of the world's deep lakes and information that is useful to Park management is provided. As part of the Pacific coastal biogeographic regional Global Climate Change Studies Program, Crater Lake now offers a unique opportunity to study a closed watershed system, to understand Lake response to climatic variability and to obtain an improved understanding of the effects of El Nino/Southern Oscillation (ENSO) events upon natural resources in the Pacific Northwest (Larson et al., 1992).

Conclusions

The research strategy of the NPS watershed research program is to address several complex natural resource issues challenging the successful management of park and preserved lands. Our activities emphasize multi-institutional, interdisciplinary, and integrated watershed research studies within protected areas having representative ecosystem or biome values. Essential continuity is provided between the watershed research sites by coordinated efforts to collect equivalent and comparable data sets. The broad watershed design focuses sites toward meeting important long-term objectives that emphasize the importance of testing site-specific and inter-site hypotheses. The program has demonstrated utility for developing, testing, and implementing state-of-the-art scientific methods and procedures for guiding collection of relevant data in support of trends analyses. The lessons learned are now providing important information to new Global Climate Change Program efforts and to the NPS national inventory and monitoring initiative and are relevant to future natural land and water resources management, locally, nationally, and internationally. Watershed research is cooperating with both in-house and numerous external programs, greatly enhancing the long-term value and impact of our results.

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Statistical Modeling of Water Quality in Regional Watersheds

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A long-standing problem in hydrology is to describe the water quality of a large area such as a state or regional drainage basin using measurements collected at a network of sampling stations in the area. Water quality descriptions for a large area are often desired either in map form or in the form of frequency distributions giving the number of miles of streams in the area which meet specified standards or can be categorized in other meaningful ways. Such analyses are usually complicated by: sparseness of sampling locations that leads to problems in interpolating between those locations; and spatial biases in the sampling network that result in an unrepresentative sample of stream conditions. For example, if a disproportionate number of sampling stations are located on streams that drain densely populated, heavily industrialized, or intensively cultivated watersheds, the data will likely present a poorer picture of water quality than actually exists.

Given an appropriate statistical methodology, information on basin attributes that can affect water quality, such as land use, population, and pollutant discharges, can be used to help solve both problems. This paper describes a recently developed methodology for statistically modeling water quality over large areas. The objective is to develop a set of techniques to:

1. Relate water quality measurements to information on basin characteristics and pollution sources in an area the size of a state or regional drainage system.
2. Use these relations to derive statistically valid summaries of water quality conditions in the area.
3. Use the relations to investigate the relative importance of factors influencing water quality in the area and the effectiveness of proposed management strategies.

The methodology integrates statistical and deterministic modeling techniques in a geographic information system. In order to deal efficiently with large areas, the methodology is designed to accommodate a variety of remotely sensed data on basin characteristics.

To illustrate the methodology, this paper describes a model of total phosphorus (TP) concentrations in nontidal streams in New Jersey. Nontidal streams in the state encompass a total 9,157 kilometers which, for modeling purposes, have been segmented into 7,213 stream reaches. The model covers a total area of 15,401 square kilometers. As an example application, the model is used to analyze the potential effects of a phosphate detergent ban on the statewide distribution of TP concentrations.

The model described in this paper was developed as part of a larger effort to statistically model several additional aspects of water quality in New Jersey streams, including nitrate-nitrogen and fecal-coliform bacterial concentrations, and an index of the health of warm-water fish communities.

Model Description

The mathematical core of the model is a regression equation relating TP concentration at a given stream location to measures of point and nonpoint sources of phosphorus in the watershed upstream of that location. The regression equation is of the form

$$\ln(C) = B_0 + B_1 \ln(S_1) + \ldots\ldots\ldots + B_n \ln(S_n) + E \quad (1)$$

where:

C is mean TP concentration at a specified stream location (model node);

B_i are linear regression coefficients;

S_i are predictor variables representing categories of point and nonpoint sources of phosphorus (municipal treatment plants, urban runoff, for example) located upstream of the specified node; and

E represents normally distributed model error.

Predictor variables are formulated as:

$$S_i = \sum^{\text{all j}} L_{ij} \exp(-k_i D_j) / Q \quad (2)$$

where:

L_{ij} is a measure of the load of phosphorus from source i in sub-basin j;

D_j is the distance of sub-basin j from the specified node;

Q is mean streamflow at the specified node; and

k_i is the first-order distance decay coefficient for phosphorus from source i.

TP concentrations in streams are assumed to decrease exponentially with distance from phosphorus sources as a result of both sedimentation from the water column and biological uptake. Logarithmic transformation of terms in Equation 1 was found to result in more normally distributed regression residuals than an untransformed model.

Digital elevation data (90-meter grid) and the method of Jensen and Domingue (1988) were used to define drainage divides for a set of 2921 contiguous "sub-basins" covering all nontidal drainage in New Jersey. The sub-basins have a median area of 2.05 square kilometers and are linked in a network of 11,063 stream segments based on 1:100,000 scale digital files (USGS, 1989). A statewide contour map of mean streamflow per unit drainage area for the period 1982-87 was used to estimate streamflow for a set of 7,213 nodes representing the junctions of stream segments. These nodes serve as water quality prediction points in the model.

Water Quality Predictors

Three variables were selected to serve as model predictors representing different sources of phosphorus within sub-basins: area of agricultural land; total human population; and total municipal effluent flow. Sub-basin agricultural land area was determined through classification of Landsat Thematic Mapper data for August, 1985 using the method of Jensen and others (1982). Sub-basin population estimates were obtained from the 1980 Census of Population and Housing (U.S. Census Bureau, 1983). Total municipal effluent flow within sub-basins was determined from a file of effluent characteristics for the year 1986 for individual municipal and industrial point sources in New Jersey (Robinson et al., 1992).

The algorithm for downstream aggregation of distance-weighted predictor data in accordance with Equation 2 is given by White and others (1992).

Regression Analysis

Observations of mean TP concentration for 104 sampling locations in New Jersey for the years 1982-87 were obtained from long-term monitoring records. Although there are a few cases of nested basins among the 104 monitoring stations, an assumption of statistical independence of the monitoring records was made in conducting the regression. Results of the regression of mean TP concentration on the three predictors are given in Table 1. Values of k_i were estimated as those resulting in the highest R^2 in a trial-and-error series of univariate regressions of mean total phosphorus on each individual predictor. Significance estimates of regression coefficients (Table 1) are not adjusted for the process of k_i estimation.

Model Application

The above model was used to estimate frequency distributions for TP concentra-

Table 1. Results of the regression of mean total phosphorus (TP) concentration on three characteristics of the basins upstream of the locations where TP concentrations were measured.

Predictor	Coefficient Value, B_i	Significance Level, p	Distance Decay rate, k_i, per kilometer
Municipal flow	0.6277	0.0001	0.01
Cropland area	0.1511	0.0058	1.0
Population	0.0796	0.0946	0.1
Regression constant	0.7421		

$R^2 = 0.55$.
Standard error of estimate = 72 percent.

tions at two sets of model nodes representing two scenarios described below (Table 2; Figures 1 and 2). Frequency distributions give the percentage of nodes in the state (or subregion of interest) that fall in each of five concentration intervals. The percentage of nodes in each interval was estimated as

$$P(C_i) = \Sigma p_j(C_i)/n \qquad (3)$$

where:
$P(C_i)$ is the percentage of nodes in the ith concentration interval;
$p_j(C_i)$ is the probability that the actual total phosphorus concentration at node j lies in interval i; and
n is the total number of nodes in the state (or subregion).

The probability that total phosphorus concentration at an individual node lies in the ith interval was estimated as

$$p_j(C_i) = p_j(t_U) - p_j(t_L) \qquad (4)$$

where: $p_j(t_U)$ and $p_j(t_L)$ are nonexceedance probabilities associated with a t-distribution with n-k degrees of freedom, where k is the number of parameters estimated in the regression model, and t_U and t_L are $(\ln C_U - \ln C_j)/S_j$ and $(\ln C_L - \ln C_j)/S_j$, respectively, in which C_L and C_U are the upper and lower limits of the concentration interval, C_j is the regression estimate of the concentration at node j, and S_j is the standard error of prediction for $\ln C_j$.

Frequency distributions are shown (Table 2; Figures 1 and 2) for two scenarios relating to assumptions regarding the magnitude of point source phosphorus loading from municipal treatment plants. The first, or base, scenario assumes phosphorus loads from all sources are equal to 100 percent of their actual 1986 values (see previous section on water quality predictors). The second scenario assumes a 25 percent reduction in phosphorus loading from municipal treatment plants that currently have no permit requirement for total phosphorus. A 25 percent reduction is the approximate change in municipal loads that has been observed to date in states with detergent phosphate bans in effect (Lee and Jones, 1986). The second scenario assumes that the 10 treatment plants in New Jersey that currently have permit requirements for TP would continue to discharge phosphorus at their base levels.

Results in Figure 1 are for all 7,213 nodes in the model, and results in Figure 2 are for the 1,643 nodes located downstream of municipal point sources.

Results

Figure 1 indicates that a 25 percent reduction in municipal point source loads of total phosphorus would have only minimal effects on the statewide frequency distribution for total phosphorus concentration in New Jersey streams. For example, a total 36.3 percent of model nodes are predicted to

Table 2. Estimated percentage of model nodes having total phosphorus concentrations within indicated intervals given municipal phosphorus loadings of 100 percent and 75 percent of 1986 levels. Results are shown separately for all model nodes (7,213) and for those located downstream of municipal point sources (1,643).

Concentration Interval (milligrams per liter)	100 Percent Loads		75 Percent Loads	
	7,213 nodes	1,643 nodes	7,213 nodes	1,643 nodes
0 to 0.05	0.140	0.140	0.142	0.087
0.05 to 0.1	0.223	0.150	0.227	0.164
0.1 to 0.3	0.416	0.375	0.419	0.387
0.3 to 1.0	0.188	0.293	0.184	0.275
above 1.0	0.033	0.104	0.029	0.085

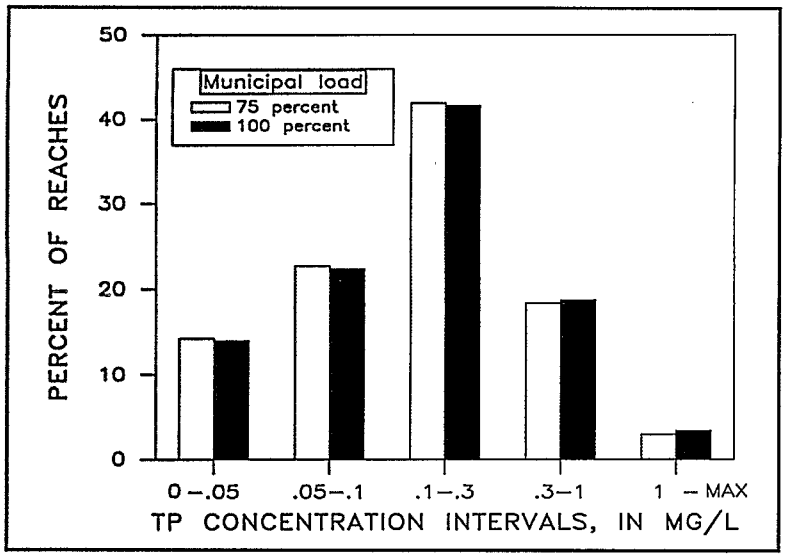

Figure 1. Estimated percentage of model nodes having total phosphorus concentrations within indicated intervals given municipal phosphorus loadings of 100 percent and 75 percent of 1986 levels. Results are for all 7,213 model nodes in New Jersey.

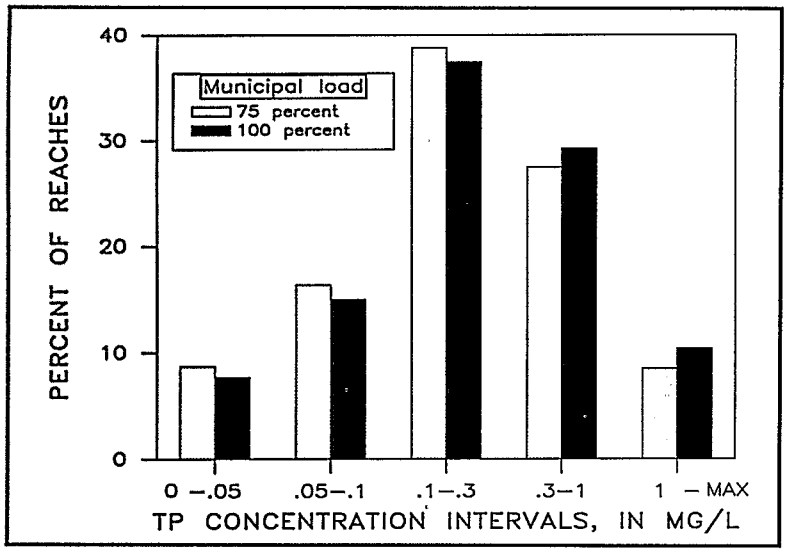

Figure 2. Estimated percentage of model nodes having total phosphorus concentrations within indicated intervals given municipal phosphorus loadings of 100 percent and 75 percent of 1986 levels. Results are for the 1,643 model nodes located downstream of municipal discharges in New Jersey.

have TP concentrations below the 0.1 milligram per liter (mg/l) New Jersey standard under current loadings, whereas 36.9 percent of model nodes are predicted to meet the standard following a 25 percent reduction in municipal total phosphorus loads (see Table 2 for precise figures). The predicted effect of load reductions is similarly small at the high end of the range of TP concentrations. A total 3.3 percent of model nodes are predicted to have TP concentrations greater than 1.0 mg/l under current loadings, whereas 2.9 percent of model nodes are predicted to exceed that concentration given a 25 percent reduction in municipal loads.

Part of the reason that predicted effects of municipal load reductions on statewide TP concentrations are small is that only a small fraction (approximately 23 percent) of model nodes lie downstream from municipal outfalls and receive any effect at all. When only the 1,643 model nodes located downstream from municipal treatment plants are considered, 22.8 percent are predicted to have TP concentrations meeting the 0.1 mg/l standard under the current loading scenario, compared to a predicted 25.1 percent of model nodes meeting the standard following a 25 percent reduction in municipal loads (see Figure 2 and Table 2). Thus, when the analysis is limited to New Jersey streams affected by municipal effluents, a 25 percent load reduction is predicted to result in approximately a 10 percent increase in the number of nodes meeting the standard.

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The Role of Inland Water Development in the Systemic Alteration of the Coastal Zone Environment

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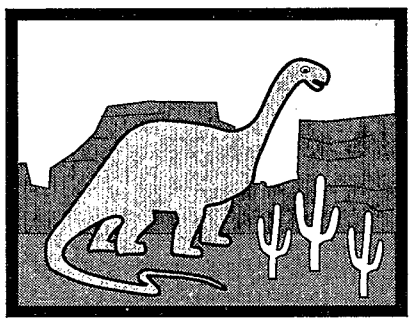
In any given season or year, interaction and mixing processes between river flow and seawater determine spatio-temporal distribution of hydrophysical and biological properties of estuarine and coastal water. Strictly defined renewable runoff discharge serves as a physical barrier preventing the intrusion of seawater into the delta or performing critical mixing and flushing of estuarine-coastal waters. These habitats serve as nursery and breeding grounds for many commercially important species of fish and shellfish directly or indirectly estuarine-dependent. (Chambers, 1992; Rozengurt, 1983; Rozengurt and Hedgpeth, 1989).

Despite having evolved diverse physiological mechanisms to ensure their survival, even hardy estuarine animals and plants have tolerance limits that may be exceeded by prolonged exposure to extreme conditions related, for example, to *dams*, *diversions*, *deforestation*, and *dewatering*—the 4Ds (Figure 1). The western Pacific and central and south Atlantic coastal fisheries have experienced the effect of the 4Ds with frightening similarity to the despoliation of the fisheries of the eastern Mediterranean sea linked to the Aswan High Dam operation on the Nile River. The same patterns of devastation have been recorded in the last two decades due to watershed modification of the Black, Caspian, Azov, and Aral Seas. Taken together, these are signals from nature that must be heeded at our greatest future peril (Rozengurt, 1991).

River-Delta-Estuary-Coastal Zones as Natural Systems

Historically, the dynamic behavior of estuarine characteristics are based on four major fundamental principles: *stochastic*



1. DAMS
2. DIVERSIONS
3. DEWATERINGS
4. DESERTIFICATIONS

Figure 1. Watershed management: the four insidious D's.

and *stochastic-periodic* nature of estuarine environment; *dynamic equilibrium*; *ecological continuity* of the river-estuary-sea ecosystem; and *biological tolerance*. The following is a brief, simplified description of the universality of these principles, which are a part of the Laws of Thermodynamics:

1. Stochastic nature of river runoffs (the precipitation over watersheds) and stochastic-periodic variability of the coastal processes (tide and wind) determine the natural randomness of estuarine characteristics in time and space.
2. The probabilistic nature of unimpaired runoff superimposed on tide, oscillations, and winds is responsible for setting in motion an amount of estuarine and coastal waters 10 to 100 times greater than that of the river runoff itself. This frictional drag provides enrichment of estuarine and coastal waters and maintains a suitable regime for vulnerable, but resilient estuarine biota.
3. The estuarine ecosystem may be conceptually perceived as an ecological continuum of a river. These waterbodies have evolved for thousands of years and acquired regime characteristics of watersheds and coastal zones. In any given time, the kinematic energy of river runoff governs the recycling of a certain ratio of major chemical constituents and repulses salt intrusion; determines relationships with community production and respiration; and commands entirely the vitality and survival of estuaries (the first law of thermodynamics).
4. In this context, the tolerance or biological self-adjustment means the ability of estuarine hydrobionts to recover from exceptionally low levels of population density as a result of extreme natural perturbations. These hydrobionts can reach the near historical reproduction when unimpaired dynamic equilibrium was restored. However, the impoundment of rivers has undermined these unique estuarine features and significantly hampered the ability to maintain ecological continuity suitable for indigenous living resources (the second law of thermodynamics). In this case, the physiological adaptation of eggs, larvae, and even fry to abnormal increases in salinity will not occur because the salinity and other regime variables affect differently their osmoregulation, metabolism, growth rate, and survival. As a result, the brackish nursery areas vital for migration, feeding, and spawning start to gradually diminish (entropy - accumulation of negative substances).

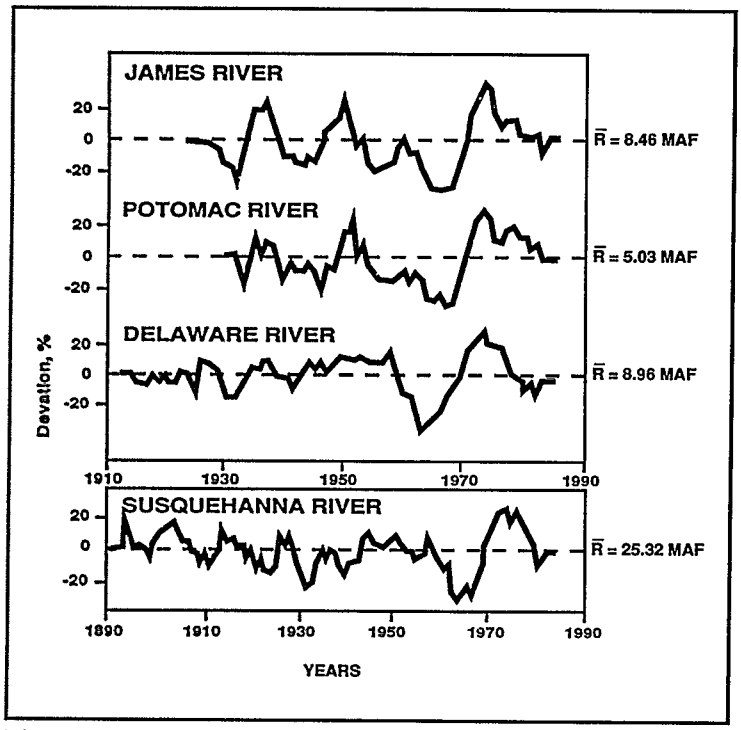


Figure 2. Percentage deviation of the 5-year running mean annual runoff of normals for major rivers of central Atlantic ($\bar{R}$ - normal runoff over the period.)

Some Examples of Watershed Overdevelopment

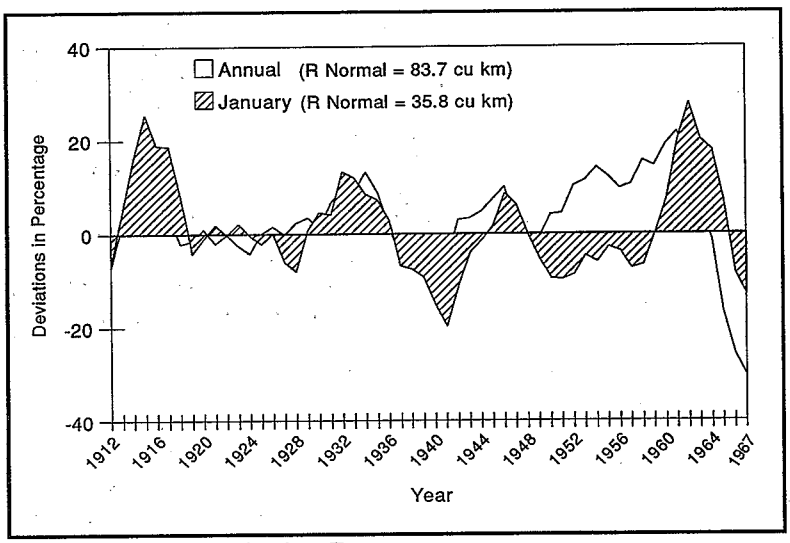
Over the last few decades a cascade of dams has curtailed nearly all critical ecosystem links; truncated the values, duration, and vitality of spring flooding; and modified its stochastic patterns into deterministic, impaired seasonal remnants far beyond nature's limit (Rozengurt, 1971, 1974). For example, the historical deviations of spring as well as annual runoff discharges equaled plus or minus 25 to 30 percent of their normals (Figures 2 and 3) as opposed to the abnormal deviations up to minus 40 to minus 85 percent after the impoundment occurred (Rozengurt et al., 1985). As a result,

the cumulative losses in runoff discharges as well as sediment load, organic and inorganic matter, oxygen, and other resources in many regions exceed 100 million tons. Subsequently, these man-made deficits have become chronic abnormal events. By definition, cumulative losses are an integrated result(s) of accumulation in space and time of negative substances whose physical and chemical interaction may lead to a gradual increase of entropy. The latter, in turn, aggravates (deteriorates) ecosystems in a way unseen or undocumented under natural or unimpaired conditions. Consequently, the natural ecological, unimpaired equilibrium cannot be maintained. For example, since the late 1960s the San Francisco Bay has been systematically deprived of annual and especially spring runoff far beyond reasonable standards (Figure 4). Subsequently, the commercial and sport fishery of striped bass, shad, and salmon has almost ceased to exist. The same situation has led to irrevocable distortion of the Black, Azov, Caspian, and Aral Seas, the Columbia and Colorado Rivers, the Gulf of Mexico, etc. Coastal ecosystems are being transformed into "blue deserts."

Since the 1950s, the majority of regulated river-coastal ecosystems have been striving under subnormal dry or drought conditions regardless of wetness of the year. The frequency of these events has increased 3 to 5 times (Rozengurt and Haydock, 1991, 1993). This new phenomenon has inflicted a mortal blow to watershed and coastal ecosystems. The same fundamental changes are typical for the coastal zone of the Nile River where runoff, silt, and nutrients have been reduced to 10 to 20 percent of normal. This, in turn, has led to a ten-fold decline in the catch of eastern Mediterranean sardines and prawns (Halim, 1991).

Another abnormal phenomenon exists in the intra-annual runoff distribution; the late summer-fall runoff is almost equal to or higher than the regulated spring runoff because of agricultural drainage water releases. The resulting symptoms of stress—decreases in fish production and catches, increased residence time for pollutants, increases in salinity, and widespread oxygen depletion (hypoxia)—have plagued numerous deltas, estuaries, gulfs, or even whole seas.

Losses from water development facilities are particularly impressive when compared to those suffered from all other causes



Source: Ministry of Irrigation, Egypt.

Figure 3. Percent deviation of the Nile 5-year running mean annual and winter runoff at Aswan.

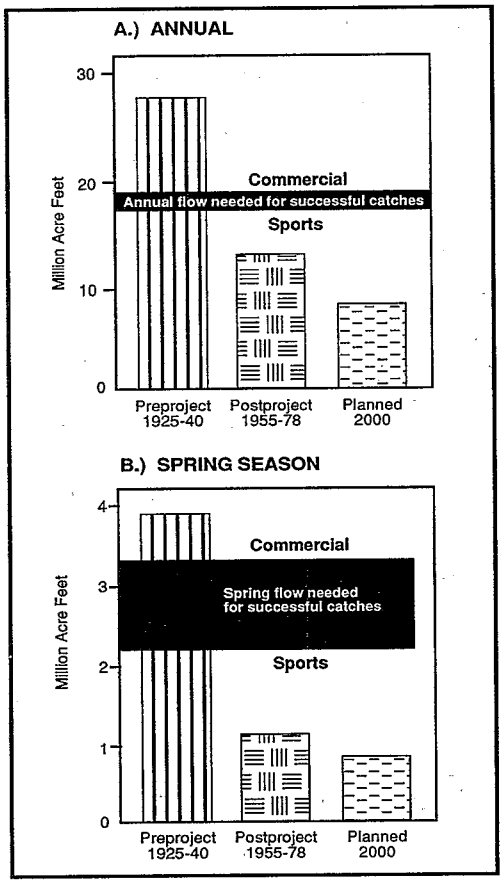


Figure 4. Water needs for successful commercial and sports fishing in the San Francisco Bay coastal zone ecosystem compared to State Water Project flow. A.) annual and B.) spring season.

in the U.S. coastal areas. In California abnormal timing of flows in the Sacramento-San Joaquin rivers, coupled with fish kills on screens of water conveyance facilities, exacerbated the deleterious effect of unrestrained water diversions. For example, the losses from all reported fish kills for 22 coastal states between 1980 and 1989 (Figure 5, Lowe et al., 1991) were slightly less than the carnage of 100 million fry at the Delta pumping facilities (California Department of Fish and Game, 1992). Note that the cumulative losses of 1.2 billion striped bass fry and salmon smolt since 1957 have been three times higher than the fish kill for the same states for the later period. While screening was the major killing factor in the delta, low oxygen triggered by eutrophication was the major cause of fish kills in the Gulf and Atlantic coasts. Incidentally, wastewater discharges accounted for only 6 percent of the over 400 million fish that died between 1980 and 1989.

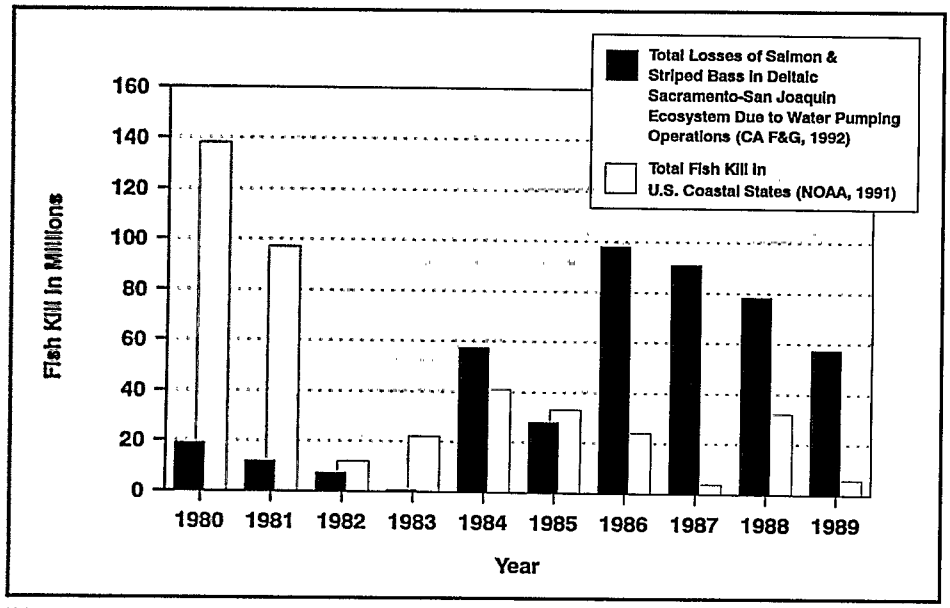


Figure 5. Comparison of chronological integrated fish losses between coastal states and Sacramento-San Joaquin River systems.

Today the formerly rich fisheries of the Black, Azov, Caspian, and Aral Seas of the former U.S.S.R. must be considered only in the deficit column (Figure 6). The monetary losses amount to $100 billion for the last decade, if population and economic hardship are taken into account; the Aral Sea is now completely lost for mankind. A similar fate is predicted for other watershed and coastal zone ecosystems where water development has been overly optimistic (Rozengurt and Herz, 1981).

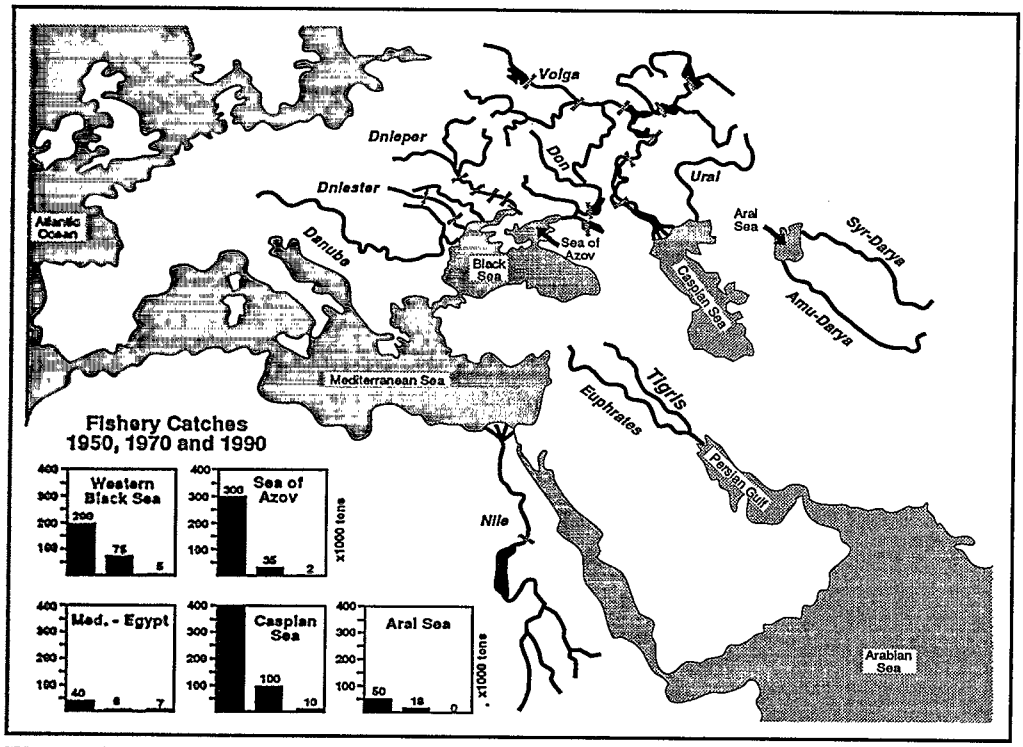
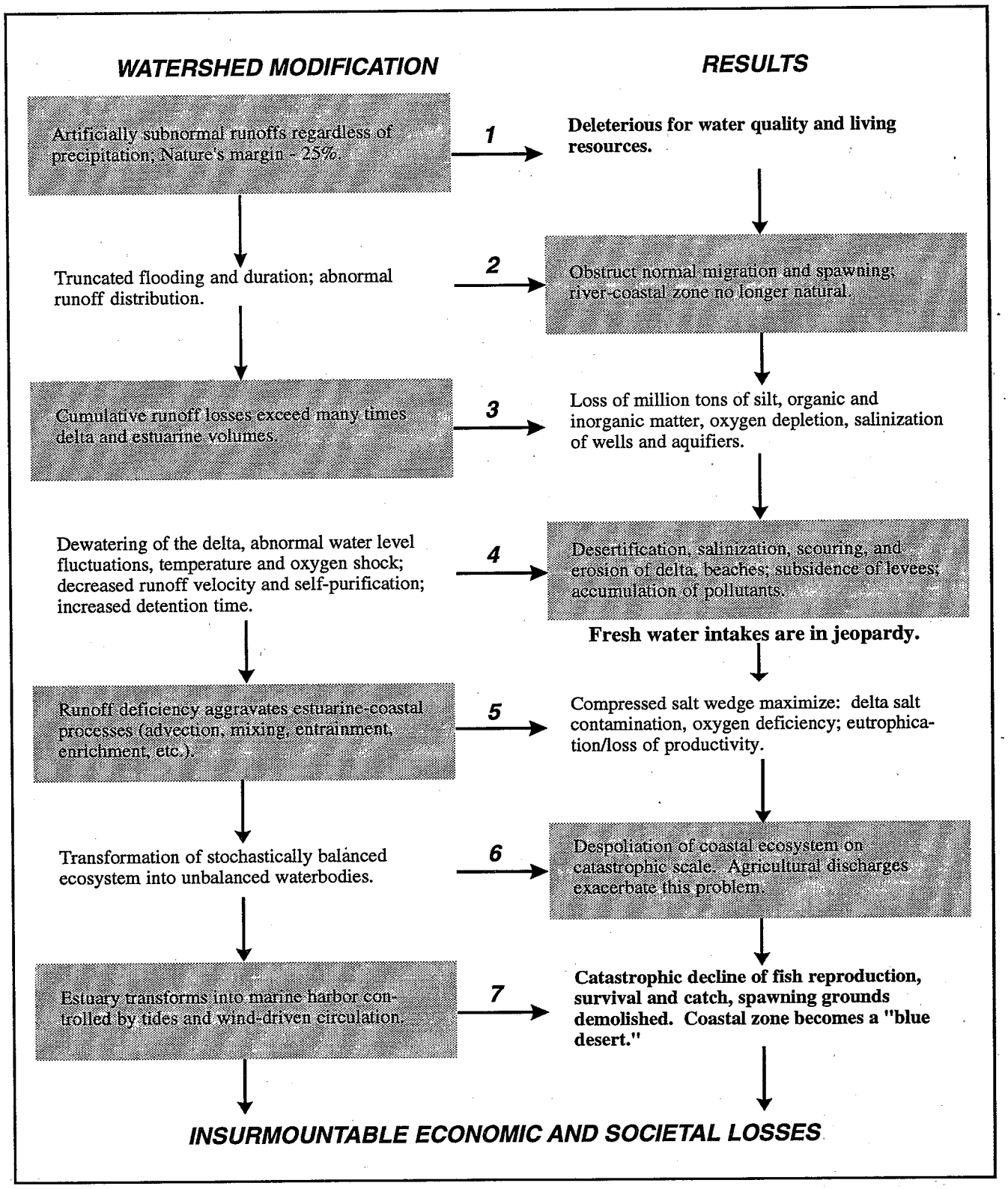


Figure 6. Decline of commercial fish catch due to the impoundment of the major river systems in the former U.S.S.R.

Conclusions

The chain of events leading to the systemic aggravation of regime characteristics and decimation of living resources of the delta-estuary-coastal zone ecosystems, because of excessive impoundment and water withdrawals, is summarized in Table 1.

Table 1. Irrevocable distortion of river-delta-estuary-coastal ecosystem



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Quantification and Control of Nitrogen Inputs to Buttermilk Bay, Massachusetts

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Buttermilk Bay is a 530-acre (214.6-hectare) shallow coastal embayment located at the northern end of Buzzards Bay in Massachusetts (Figure 1).

This bay is flushed by diurnal tides and experiences complete tidal exchange approximately every 5 days (Valiela and Costa, 1988). Portions of three towns, Bourne, Plymouth, and Wareham, are situated within the drainage basin to this coastal embayment. Existing land use is predominantly residential and includes both high-density seasonal communities along the western and northern shorelines of the bay, and low-density development throughout most of the remainder of the drainage basin. Most development within this area relies on individual subsurface sewage disposal systems, although a few areas are currently in the process of being sewered.

Increasing nitrogen levels have been attributed to Buttermilk Bay, as evidenced by nuisance algae blooms, elevated chlorophyll concentrations (i.e., phytoplankton), and declining eelgrass beds in localized areas (J. Costa, personal communication, 1989). The bay also has a history of shellfish closures dating from 1984 caused by bacterial contamination. Previous investigations have documented that the bacterial contaminants are derived primarily from storm water runoff (Heufelder, 1988).

The purposes of the investigation were to quantify existing and potential nitrogen inputs to Buttermilk Bay derived from land development, and to recommend land management strategies to control these inputs below critical levels.

Approach

To assess nitrogen impacts to Buttermilk Bay, the ground water drainage area and surface watershed to the bay were delineated. Due to the high permeabilities and infiltration rates associated with the

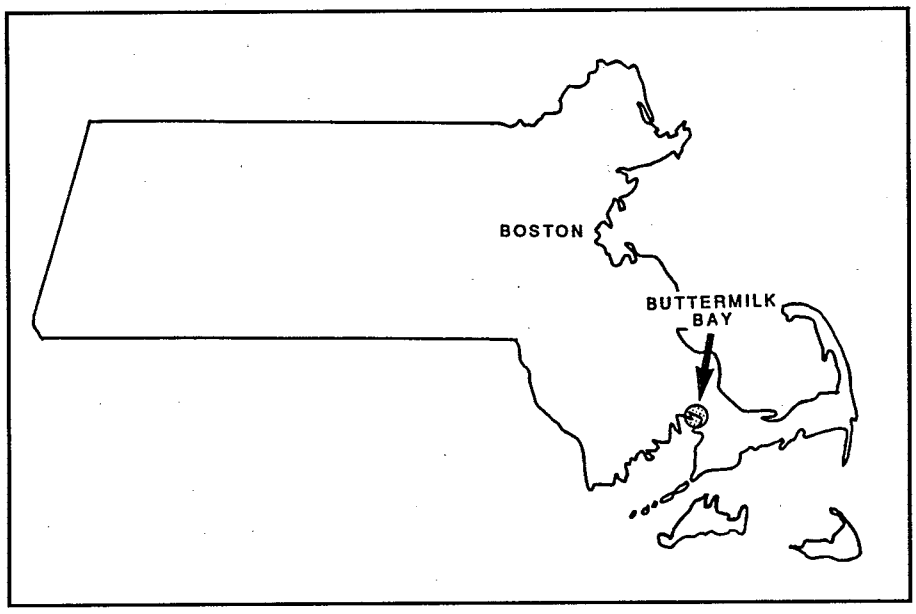

Figure 1. Locus map.

surficial geologic deposits in this area (Wareham Outwash Plain) and the relatively flat topography, surface runoff and stream formation are minimal. Therefore, the majority of the freshwater inputs to the bay are derived from ground water.

The ground water recharge area to Buttermilk Bay was delineated by first developing a regional water table contour map for the area, based on existing hydrogeologic data on file with the U.S. Geological Survey's Division of Water Resources. Twenty-two water level elevation data points were used to construct this map, corresponding to observation well measurements and pond elevation data collected in December 1984.

Ground water flow divides and recharge area boundaries were determined using a two-dimensional ground water flow net analysis. The surface watershed was determined topographically. The data point locations, water table contours, and drainage area are presented in Figure 2.

The impacts of existing and potential development within the Buttermilk Bay study area were evaluated with a buildout, or developable lot, analysis. The ground and surface water contributing area boundaries were transferred to assessor's maps for each town. Existing land uses within these areas were documented and the potential for further development was determined. Existing and potential development for each parcel was determined based on lot area, road frontage, and local zoning requirements. Development options included vacant lots and vacant parcels that could be divided through an "Approval Not Required" (ANR) process (Massachusetts General Laws, Chapter 41, 81-P), or a Definitive Subdivision Plan (MGL, Chapter 41, 81-L), or through a combina-

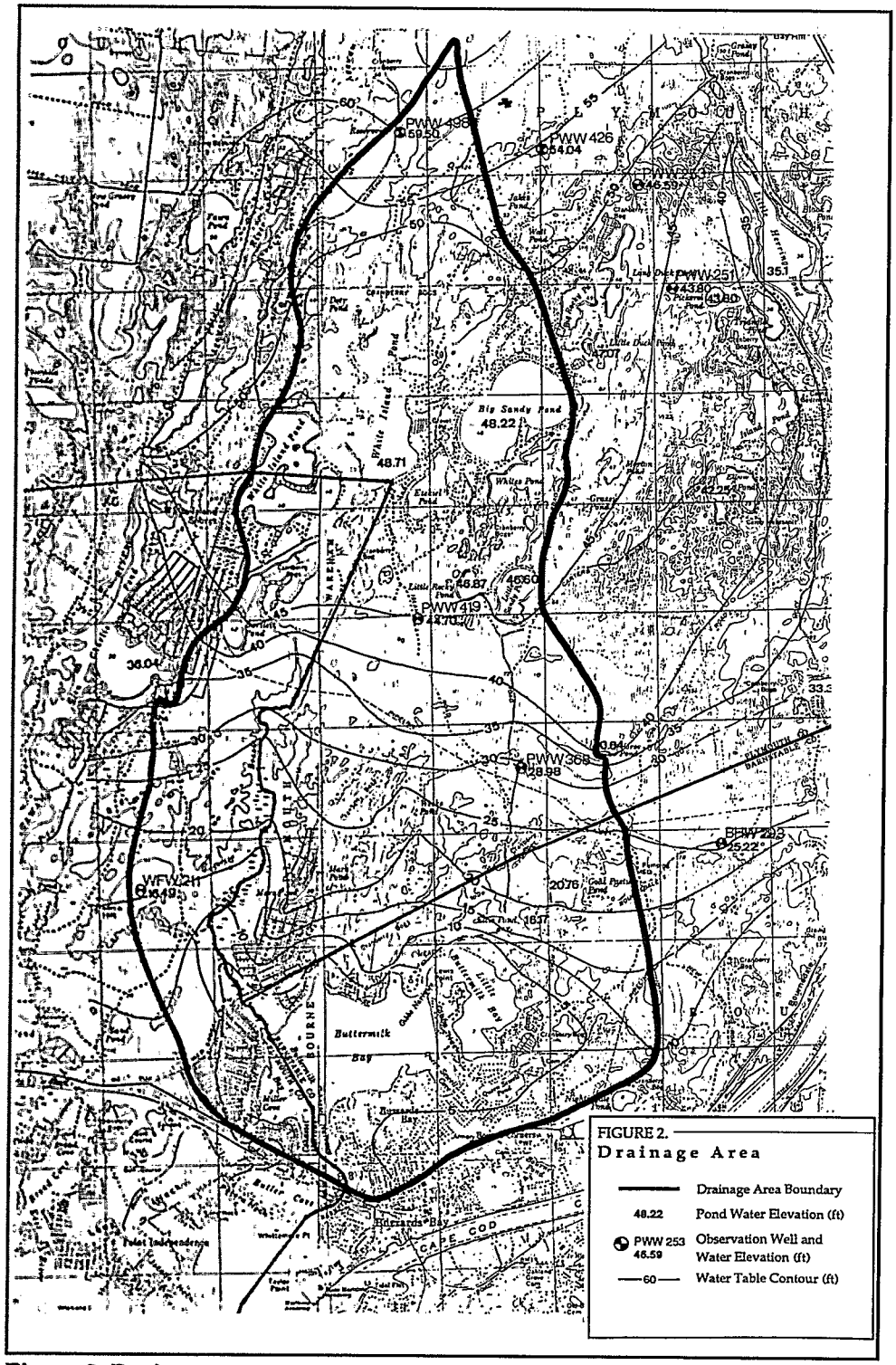

Figure 2. Drainage area.

tion of the two processes as allowed by the Subdivision Control Law. Existing and potential development information was gathered for each town from a variety of sources, including assessors' maps, tax printouts, land use codes, zoning maps, and zoning bylaws.

To evaluate potential nitrogen impacts on Buttermilk Bay, a nitrogen loading analysis was conducted. Although all forms of nitrogen are critical components of natural systems, nitrogen can cause water quality degradation if present in excessive quantities. In many marine systems, nitrogen is generally considered to be the limiting nutrient for growth. Elevated levels may cause excessive plant growth and other symptoms of eutrophication. Excessive nitrogen may cause epiphytic algae growth on eelgrass, disrupting its photosynthetic processes and ultimately resulting in eelgrass bed declines. The precise relationship between nitrogen loading and marine productivity has not been well documented and varies widely, depending on the physical and biological characteristics of a given system (water depth, flushing rate, sediment type, extent of bordering wetlands, dominance of phytoplankton versus macroalgae, etc.).

Nitrogen originates from a variety of natural and anthropogenic sources, including sewage, fertilizers (residential and agricultural), road runoff, precipitation, landfills, wildlife, and sediments. Loading rates were selected for each of the major nitrogen sources in the Buttermilk Bay drainage area on the basis of a literature review, and also to correspond with a recently calibrated nitrogen loading model developed for the Town of Yarmouth, Massachusetts (Nelson et al., 1988). The loading rates used in our analysis are summarized in Table 1.

Nitrate-nitrogen concentrations in ground water were calculated using a mass balance equation, in which nitrogen levels are a function of the annual rate of nitrogen loading and the annual rate of dilution through recharge:

NO_3-N,mg/l = (N loading, lb/yr) (454,000 mg/lb)/recharge, liter/yr.

Sources of recharge to ground water include precipitation, surface runoff from impervious areas, and artificial recharge from on-site sewage disposal. Recharge rates used in the nitrogen loading analysis are shown in Table 1.

In managing nitrogen inputs to coastal waters, there have been several attempts to define a "critical" nitrogen concentration for estuarine waters at which symptoms of cultural eutrophication may begin to develop. For example, the Town of Falmouth (1988) adopted a three-tier nitrogen concentration approach intended to limit future nitrogen inputs: 0.32, 0.50, and 0.75 mg/l as critical concentrations for waterbodies of varying water quality and usage. Similar approaches have been adopted by other municipalities on Cape Cod.

The EPA-sponsored Buzzards Bay Project recommended that a critical nitrogen loading rate be established for anthropogenic sources of nitrogen to Buttermilk Bay that would be independent of measured nitrogen concentrations in the water column. They tentatively adopted 240 mg per cubic meter per residence time ($mg/m^3/R$) as the critical loading rate for nitrogen-sensitive embayments such as Buttermilk Bay (HWH, 1991). More recently, the Buzzard's Bay

Table 1. Nitrogen loading analysis parameters

Source	Concentration	Loading Rate	Flow/Recharge
Sewage	40 mg N/liter	(6.72 lb N/person-yr)	55 gallons/person-day (165 gallons/dwelling)
Fertilizer (Lawns)		(0.9 lb N/1000 sq ft-yr)	18 inches/year
Fertilizer (Cranberry Bogs)		(15.8 lb/acre)	18 inches/year
Pavement Runoff	2.0 mg N/liter	(0.42 lb N/1000 sq ft-yr)	40 inches/year
Roof Runoff	0.75 mg N/liter	(0.15 lb N/1000 sq ft-yr)	40 inches/year
Acid Precipitation to Bay	0.3 mg DIN[a]/liter	(3.03 lb N/acre)	
Average Loading Rate Per Dwelling		(25.3 lb/yr)	

[a] DIN = dissolved inorganic nitrogen.
Source: Adapted from Nelson et al., 1988.

Project has revised this standard to a tiered approach reflecting state water quality standards, flushing of the coastal system, and special designations (J. Costa, personal communication, 1991). The current recommended nitrogen loading limits for shallow, rapidly flushing embayments such as Buttermilk Bay are 350 mg/m³/Vr for waters classed as SB, 200 mg/m³/Vr for SA waters, and 100 mg/m³/Vr for areas classed as sensitive outstanding resource areas. Vr is a flushing term defined as:

Vr = residence time/sqrt(1 + residence time).

The annual nitrogen loading to ground water required to reach the 240 mg/m³/R critical rate can be calculated if the surface area, volume, and flushing rate of the bay are known. These values were taken from a recent publication on Buttermilk Bay (Valiela and Costa, 1988) and were used to calculate the critical annual loading rate as follows:

A = Area of Buttermilk Bay = 214.6 ha (530 ac)
d = Water depth (MLW) = 0.9 m (2.95 ft)
r = Average tidal range = 1 m (3.28 ft)
V = Bay volume at mean tide = (A)(d+r/2) = 2,996,000 m³ (84837 ft³)
f = Flushing rate = 5 day residence time or 73 times per year
TN = Total nitrogen concentration (mg/m³/R)
L = Critical loading rate (lb/yr) producing TN = 240 mg/m³/R
L = (TN)(V)(f)/454,000 mg/lb.

Table 2. Buildout analysis results

	Wareham	Plymouth	Bourne	Total
Existing Land Use				
Residential units	755.0	1,075.0	1,219.0	3,049.0
Commercial units	28.0	0	11.0	39.0
Cranberry bogs (acre)	52.2	335.4	11.0	398.6
Open space (acre)	206.1	663.3	125.7	995.1
Potential Land Use				
Vacant (grandfathered) lots	222.0	350.0	128.0	700.0
Approval Not Required lots	9.0	359.0	147.0	515.0
Subdivision lots	90.0	639.0	321.0	1,050.0
Total Lots	1,106	2,423	1,826	5,355
% Developed	71%	44%	67%	57%
Area (acres)	1,395.0	4,160.0	1,398.0	6,953.0
Existing density (units/acre)	0.6	0.3	0.9	0.4
Buildout density (units/acre)	0.8	0.6	1.3	0.8

Table 3. Existing nitrogen loading

Source	Wareham	Plymouth	Bourne	Total
Sewage	20,013	21,590	25,337	66,940
Lawn fertilizers	3,398	4,838	5,486	13,721
Cranberry bog fertilizers	835	5,366	176	6,378
Roads	413	646	665	1,723
Roofs	170	242	274	686
Acid precipitation to Bay				1,606
Total Loading	24,829	32,682	31,937	91,053
(Pounds Per Year)				
Predicted average NO_3-N (mg/l) in ground water	3.86	1.83	4.75	2.94

Results

The drainage area was found to comprise a total of 6,953 acres (2,815 ha). Twenty percent of this area (1,398 acres) is located in the Town of Bourne, 60 percent (4,160 acres) in Plymouth and 20 percent (1,395 acres) in Wareham. It should be noted that the boundaries are based on available data; with more information, it is possible that the contributing area boundaries would change.

The results of the buildout analysis (Table 2) indicate that 3,049 residential units and 39 commercial units currently exist within the Buttermilk Bay drainage area. An additional 2,267 units could eventually be constructed under full buildout conditions; i.e., the drainage area is currently 57 percent developed.

Annual nitrogen loading for all existing sources of nitrogen within the Buttermilk Bay drainage basin was calculated to be 91,053 lb/year. Seventy-four percent of this nitrogen is derived from on-site sewage disposal, followed by lawn fertilizers (15 percent), cranberry bog fertilizers (7 percent) and other sources (4 percent). Results are shown in Table 3.

Calculated nitrogen loading under buildout conditions with three people per housing unit is shown in Table 4. The majority of the nitrogen under buildout conditions is derived from on-site sewage disposal (72 percent), followed by lawn fertilizers (19 percent), cranberry bog fertilizers (5 percent); and other sources (4 percent). The total pounds nitrogen per year

represents a potential increase of 39 percent over existing conditions.

Under the 240 mg/l/R standard, total "permissible loading" to Buttermilk Bay was calculated to be 115,617 lb/yr. The total nitrogen loading to the bay calculated for existing conditions is 189 mg/m^3/R above background levels. Under buildout conditions, it is 263 mg/m^3/R above background.

This represents an excess of 11,047 lb/year above the critical rate—the equivalent of approximately 437 single-family dwellings, since loading per dwelling is approximately 25.3 lb/year (11.5 kg/yr).

Table 4. Potential nitrogen loading

Source	Wareham	Plymouth	Bourne	Total
Sewage	8,837	48,663	33,863	91,363
Lawn fertilizers	4,851	10,904	8,168	23,922
Cranberry bog fertilizers	835	5,366	176	6,378
Roads	481	929	790	2,199
Roofs	243	545	408	1,196
Acid precipitation to Bay				1,606
Total Loading (lb/yr)	15,246	66,407	43,405	126,664
Predicted average NO_3-N (mg/l) in ground water	2.45	3.53	6.14	3.94

Discussion

The buildout and nitrogen analyses suggest that action should be taken to protect water quality in Buttermilk Bay. A variety of tools are available to assist in resource protection, including regulatory, nonregulatory, and legislative options. Because traditional management tools (zoning, subdivision control, and health regulations) are localized in their applicability and rarely serve to protect regional resource systems, even small systems such as Buttermilk Bay, the coordinated adoption and enforcement of strategies by all three communities in the drainage area is required.

As part of this study, several management strategies were proposed, including the creation of health and subdivision regulations, wetlands protection guidelines, and storm water management recommendations. An overlay water resource protection district was created and adopted by the three communities within the watershed. The overlay district "downzoned" (raised minimum lot size) within the watershed, effectively removing the potential for an additional 440 new single family dwellings—the number determined to be in excess of the critical loading threshold.

Acknowledgments

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Application of the Hydrologic Simulation Program—Fortran (HSPF) Model to the Potomac River Basin

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The Potomac basin drains the waters (and nutrient loads) of four states, Maryland, Virginia, Pennsylvania, West Virginia, and the District of Columbia. These states (with the exception of West Virginia), along with the federal government, U.S. Environmental Protection Agency (EPA), and the Chesapeake Bay Commission, are partners in the Chesapeake Bay nutrient reduction agreement. The agreement calls for a 40 percent reduction in the discharge of controllable phosphorus and nitrogen to the tidal bay by the year 2000. To determine the quantity of the controllable nutrient load, and to determine the efficacy of nutrient control strategies to bring this about, the entire 164,000 square kilometers of the Chesapeake Bay basin were simulated using HSPF (Hydrologic Simulation Program—Fortran). This paper describes a representative portion of this work, specifically, the water quality simulation of the Potomac basin, with emphasis on the simulation of nutrient loads delivered to the tidal bay.

The Potomac River basin covers an area of 3,638,500 hectares in the mid-Atlantic region of the United States (Figure 1). The headwaters drain the ridge and valley geology of the Appalachian Mountains. Land use in the upper basin is predominately forest (66 percent) and agriculture (29 percent). Midbasin, in the Piedmont Plateau region, agricultural land uses predominate (45 percent) on the moderate slopes. In the Piedmont, urban land use also increases in importance (15 percent). On the lower elevations and slopes of the coastal plain, urban land use further increases (25 percent), particularly in the Washington, DC, metropolitan area at the head of tide. Overall the basin is composed of 55 percent forest land, 33 percent agricultural land, and 12 percent urban land.

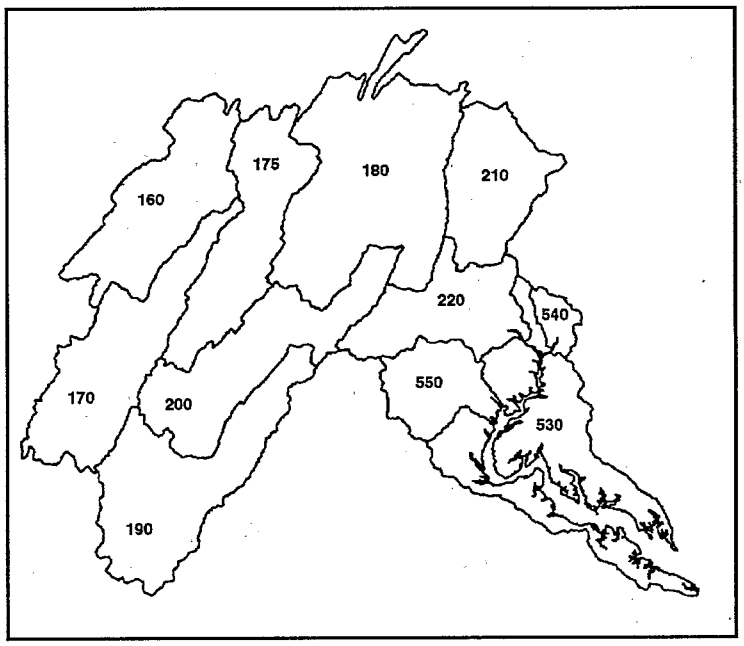


Figure 1. Model segmentation of the Potomac Basin. The Alleghany ridge and valley region includes segments 160, 170, 175, 190, and 200. The Piedmont region includes segments 180, 210, and 220. The coastal plain includes segments 530, 540, and 550.

Application of HSPF to the Potomac Basin

The HSPF Model is a modular set of computer codes that simulate hydrology, nutrient, and sediment export from pervious and impervious land uses, and the transport of these loads in rivers and reservoirs.

HSPF has been publicly available since 1980 and is supported and updated by the EPA Office of Research and Development, Athens, Georgia. Applications of HSPF have included flood assessment, drainage design, nonpoint source nutrient evaluation, pesticide risk assessment, water resource planning, and water quality management.

HSPF Release 10.0 was used for this application. Release 10.0 includes simulation of particulate nutrient transformation and transport within rivers and reservoirs, and refinements in HSPF data management (Johanson et al., 1993).

Structure

The modular structure of HSPF allows a variety of simulation options. In the following model structure description of the Potomac nonpoint source load simulation, the HSPF module names are in parenthesis.

Hydrology Modules

The Potomac hydrology simulation applied the modules of adiabatic air temperature corrections (ATEMP), snow simulation (SNOW), simulation of the water budget for pervious land (PWATER), and simulation of water budget for impervious land (IWATER).

Nutrient Load Modules

Potomac nutrient load modeling included modules which simulate sediment loads (SEDMNT), estimate soil temperature (PSTEMP), estimate soil water temperature and dissolved gas concentration (PWTGAS), and simulate pervious and impervious land water quality constituents using relationships with sediment and water yield (PQUAL, IQUAL).

Cropland was simulated with a detailed nonpoint source load simulation module (AGCHEM). AGCHEM simulates application of fertilizer, manures, atmospheric deposition, crop uptake, soil binding, denitrification, and surface/subsurface export. Nutrient load modeling of cropland includes modules which simulate the moisture and the fractions of solutes being transported in the soil layers (MSTLAY), phosphorus behavior (PHOS), and nitrogen behavior (NITR).

Transport and Transformation Modules

River and reservoir modeling includes modules of hydraulic behavior (HYDR), heat exchange and water temperature (HTRCH), behavior of inorganic sediment (SEDTRN), primary DO, BOD balances (OXRX), sediment/nutrient interactions, nitrification, denitrification (NUTRX), and phytoplankton behavior and associated reactions (PLANK).

Model Segmentation

The Potomac basin was divided into 11 model segments, each with an average area of 379,200 hectares. Segmentation partitioned the basin into regions of similar characteristics, consistent with the accurate delivery of nutrient loads at the basin terminus. Segmentation was based on three tiers of criteria. The first criterion was segmentation of similar geographic and topographic areas that were further delineated in terms of soil type, soil moisture holding capacity, infiltration rates, and uniformity of slope. The second criterion involved finer segmentation based on spatial patterns of rainfall. The third criterion ensured that physiographic segmentation was consistent with drainage sub-basins and that bankfull channel travel time of each segment was about 24-72 hours (Hartigan, 1983).

Hydrology Simulation

Data from a total of 50 precipitation stations were obtained from standard National Oceanic and Atmospheric Administration (NOAA) tape files from the states of West Virginia, Virginia, Pennsylvania, and Maryland. Of the 50 stations, 26 were hourly data and 24 were daily data.

Four calendar years were simulated, 1984 through 1987. Daily station data were converted to the necessary hourly data based on the time series data collected from a nearby hourly station that had a daily total closest to the daily data. The average precipitation for each model segment was based on the spatial distribution of the

precipitation by the Thiessen polygon method. At least six precipitation stations were used for each model segment.

Meteorologic data for the Potomac basin were partitioned between the records of two primary NOAA stations. Meteorologic data for the western portion of the basin (segments 160, 170, 175, 190, 200) were provided by standard NOAA tape files from the station at Elkins, WV. Meteorologic data for the eastern portion of the basin (segments 180, 210, 220, 530, 540, 550) were from the station at Dulles International Airport.

Each land use in each segment has a unique hydrology, through segment and land use specific hydrology parameterization. Overall, hydrology calibration was very good—within 1.0 cm difference between average simulated and observed flow over the 4-year period (observed = 37.3 cm, simulated = 36.3 cm). The correlation coefficient for the regression of log simulated flow on log observed flow is 0.84 for the 1,460 days of the 4-year period.

Nonpoint Source Load Simulation

Nutrient loads from the following sources were simulated: forest, pasture, conventional tilled cropland, conservation tilled cropland, cropland in hay, animal waste areas, atmospheric deposition to water surfaces, urban land, and point sources. The simulation of each of these loads will be reviewed in turn.

A consistent land use data base was compiled for the entire basin. The methodology used obtained particularly detailed information on agricultural lands. Principal sources were the U.S. Census Bureau series, *Census of Agriculture for 1982*, (Volume 1 Geographic Area Series) published for each state. The Census of Agriculture provided consistent, reliable data on agricultural land areas on a county basis. Combining the major cropland and other agricultural categories from the Census of Agriculture produced acreage figures by county that were then aggregated into the 11 Potomac model segments.

A multitude of other sources were used to generate the 1985 land use data base: Soil Interpretations Records (SCS-SOI-5 data file), 1984; National Resources Inventory (NRI), 1984; Forest statistics for New York, 1980; Forest statistics for Pennsylvania, 1980; Forest resources of West Virginia, 1978; Virginia's timber, 1978; U.S. Geological Survey (USGS) LU/LC GIS Data Base. The initial land use data went through two separate reviews by state planning and environmental agencies and county Soil Conservation Extension Offices. Corrections were made after each review; then the area of forest land use was finalized.

Forest Land Use

Forest Service surveys were used as an initial data set that was modified by the relative coverage of deciduous and coniferous trees (and subsequently the amount of interception storage). Information was provided by state offices of the U.S. Forest Service on a segment scale. Figure 2 portrays forest and other land use areas by geographic region.

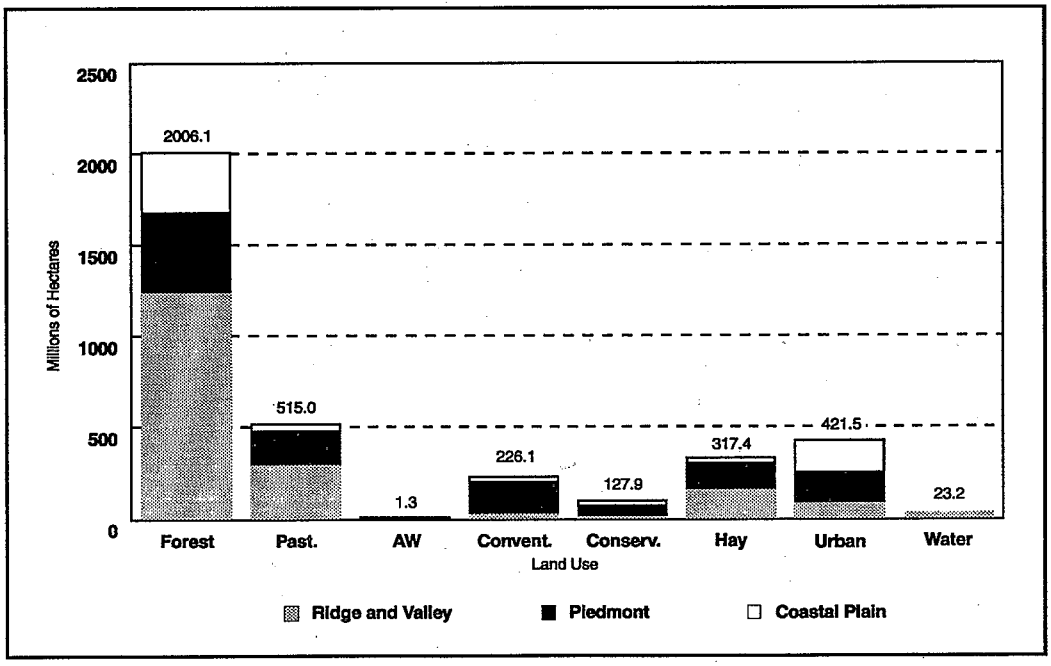


Figure 2. Land use by geographic area.

Forest calibration was through user-adjusted factors for surface and subsurface loads. A potency factor (POTFW), keyed to sediment load, is used for surface nutrient loads. Concentration factors (QUALIF, QUALGW) are used for subsurface loads. The subsurface concentration variable is applied to shallow interflow, upper ground-water flow, and lower ground-water flow. The forest land use was calibrated to expected surface and subsurface annual loads.

Pasture Land Use

Pasture land area was obtained from the 1987 Census of Agriculture by the aggregated land use of "pasture land, all types." Calibration of pasture nonpoint source loads was made to expected literature values of sediment and nutrients as described for forests.

Animal Waste

A major nutrient load in the Potomac comes from runoff from areas of concentrated livestock production. Manure acres is a derived land use that represents the production of nutrients from manure. The tons of manure produced were estimated from the numbers of livestock in the 1982 Census. Livestock numbers were adjusted to a standard animal unit and further adjusted by the application of a manure management factor.

An animal unit is defined as 1,000 pounds of animal weight, corresponding in this analysis to 0.71 dairy cows, 1 beef cow, 5 swine, 250 poultry layers, 500 poultry broilers, or 100 turkeys. The total adjusted animal units were divided by a "compromise animal density" of 145 animal units per acre, yielding the number of manure acres. Animal units of poultry, swine, beef, and dairy were further adjusted by a management factor to account for the predominant manure handling practices. Manure management factors range from zero for poultry to 1.0 for dairy cattle (Donigian et al., 1991).

The animal waste area is simulated as an average representation of manure piles, feedlots, and loafing areas. The area is simulated as impervious, with only surface roughness for (minimal) detention of input precipitation. Runoff occurs after the detention of surface depressions (0.35 in) is satisfied, and the manure nutrients associated with this runoff are 700 mg/l BOD, 70 mg/l total phosphorus (TP), and 350 mg/l total nitrogen (TN).

Conservation, Conventional, and Hay Cropland

The watershed model has three categories of cropland: conventional tillage, conservation tillage, and hay land. Conventional tillage represents fall plowed and/or spring plowed conventionally tilled cropland. Conservation tillage represents those tillage practices that result in a residue cover of at least 30 percent at the time of planting.

Tillage information on a county level was obtained for the conventional and conservation cropland distribution (CTIC, 1985). The Conservation Technology Information Center tillage data were processed to eliminate crop area overestimation due to double cropping.

Cropping patterns of conventional and conservation tillage acres were compiled from the 1982 Census from the aggregated harvested crop categories of "corn for grain," "sorghum for grain," "wheat for grain," "barley for grain," "buckwheat," "oats for grain," "rye for grain," "sunflower seed," "tobacco," "soybeans," "potatoes," "sweet potatoes," "corn for silage," "sorghum for silage," and "vegetables." Hay acres were compiled from the category of harvested "hay, alfalfa, and other tame, small grain, wild, grass silage, or green chop."

Information on fertilizer and manure application rates and timing, crop rotations, and timing of field operations was provided by state agricultural engineers and environmental scientists. Soil characteristics for nutrient interaction were obtained from the Soils-5 data base (USDA, 1984). HSPF works on an annual basis with all land use characteristics, but with a 4-year continuous record of precipitation and meteorological data. This format required a composite crop to be used. In the Potomac, the principal crop rotation is corn, soybeans, and hay. For conventional and conservation cropland, the corn, soybean composite crop was formed.

The composite crop was formed by the aggregate of crops grown on the cropland type. An average of field preparation practices, planting time, fertilizer application, and harvest was used. Parameterization of AGCHEM is fully developed in Donigian (1978).

Urban Impervious and Pervious Land Use

The USGS Land Use/Land Cover System (USGS LU/LC) was used to differentiate the urban land into five subcategories as described by Anderson et al. (1976). These land uses are: residential, 0.30 imperviousness; commercial, 0.75 imperviousness; industrial, 0.80 imperviousness; transportation/communications, 0.50 imperviousness; and institutional and parks, - 0.10 imperviousness.

Urban land imperviousness was determined for each model segment based on the five subcategories of urban land. Using the proportion of the total urban area in the different subcategories, a single area-weighted imperviousness was determined for the single aggregate urban land use modeled. The area-weighted imperviousness was used to determine the expected urban load in each model segment using the method described by Schueler (1987). The sum of the pervious and impervious urban land use load in each model segment was calibrated to this expected load.

Erosion and Sediment

Several key parameters were applied to all of the pervious land uses including forest, pasture, cropland, and pervious urban land. These parameters included cover, land slope, and the coefficient of soil fines (K factor).

Cover for conventional cropland and conservation cropland are based on the weighted area of the cover of individual crop types grown in the segment. Information on land slope and soil fines was provided by the NRI data base. Information on hydrologic characteristics of soils, such as percolation and reserve capacity, was obtained primarily from the USDA Soil Conservation Service Soils-5 data.

The delivery of sediment from each land use was calibrated to that of the expected annual sediment loads determined from the NRI data base. The model was adjusted so that the average of the annual sediment loads from 1984-87 approached that of the NRI edge of field data, with a sediment delivery factor of 0.15.

Atmospheric Deposition

Atmospheric deposition loads of nutrients were developed from the National Atmospheric Deposition Program (NADP) data base (NADP, 1982-1987). Areas of open water, such as rivers, canals, lakes, and reservoirs, were included as areas of atmospheric deposition. Water areas were determined by the USGS Land Use/Land Cover System (LU/LC) (USGS, 1974). Annual atmospheric loads of wet fall ammonia and nitrate were obtained from NADP. Atmospheric loads of dryfall inorganic nitrogen were assumed to be the long term average (1983-1989) of the wetfall nitrogen (NADP, 1982-1987). Atmospheric loads of inorganic phosphate, organic phosphate and organic nitrogen were obtained from two state-operated atmospheric stations in Maryland. Atmospheric loads were obtained on an annual basis and applied in the simulation as a load to the areas of water in the model.

Atmospheric deposition on land surfaces was included as an input load for cropland or was implicitly included in the forest, urban, and pasture land uses by calibration to the annual loads observed by field measurement.

Point Source Inputs

Data for the 4-year record were obtained preferentially from the National Pollutant Discharge Elimination System (NPDES). If no state NPDES data were available, state- and year-specific default data were calculated for each missing parameter based on sewage treatment plant flow. Industrial dischargers have highly variable flow and nutrient concentrations; therefore, industrial discharges had no defaults and were included in the data base if a load was obtained from the NPDES. The point source data were stored in model files with a monthly time step.

Surface Water Diversions

Surface water diversions were determined for each model segment. State USGS offices provided water diversion information from their computer data base. Only consumptive water use was counted as a diversion. Consumptive water use types include the USGS categories of domestic water (water used for household purposes), industrial water use, irrigation water use, and public water supply.

Results

The HSPF modules described in this paper generate nonpoint source nutrient

Table 1. Potomac unit area average total phosphorus loads by land use

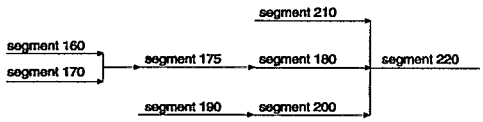
Land Use	Unit Area Load (kg/ha)	Proportion of Load Subsurface (%)
forest	0.06	21
pasture	0.36	12
animal waste	424.00	0
conventional till	3.04	22
conservation till	2.41	23
hay	1.87	18
urban	0.84	11
atmospheric loads[a]	0.65	0

[a]Loads directly to nontidal water surfaces.

loads for each land use on a unit area (hectare) basis. This load is quantified for phosphate, organic phosphorus, ammonia, nitrate, and organic nitrogen. Total phosphorus (TP) loads and the portion of the load that is subsurface are listed in Table 1.

Figure 3 shows total basin phosphorus loads into edge of stream and delivered. The quantity of the total basin load is the product of the unit area load and the land use area generating the load. For example, forest has the lowest unit area load (0.06 kg/ha), but much of the basin land use is forest (55 percent). Therefore, forest has a relatively large total phosphorus basin load of 134,760 kg. Conversely, animal waste has the greatest unit area load (424 kg/ha), but the smallest land use area (about one millionth of one percent). Basinwide total phosphorus animal waste loads are 537,570 kg.

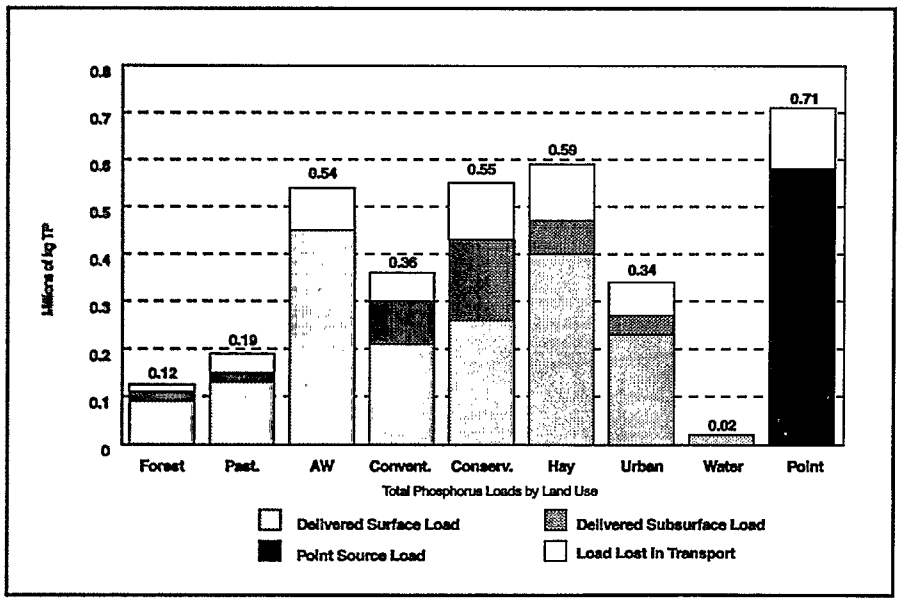
As loads are transported sequentially through model segments, loss occurs due to biological, chemical, and physical processes. Transport loss mechanisms include algal uptake and settling, particulate nutrient settling, and denitrification. The further upbasin loads are input, the greater the transport losses. Individual model segment and total transport losses of phosphorus are listed in Table 2. Model segment loss is the attenuation of load in a single model segment. Total transport loss is the total transport attenuation as loads are transported sequentially through all downstream model segments to the point of discharge to the tidal bay. Segments 530, 540, and 550 discharge directly to the tidal Potomac with no transport loss. The hydrologic connections among the other model segments are shown in the following diagram.



Average phosphorus loss in the Potomac model segments is 3 percent, ranging from -26 percent to 13 percent. The unusual negative transport loss (i.e. gain in total phosphorus) was due to a 100-year storm in the upper Potomac basin in November 1985 that scoured the bed and generated total phosphorus within model segments 170, 175, and 190.

Sources of delivered phosphorus loads to the Potomac are dominated by agriculture (Figure 4). Agricultural phosphorus loads are 65 percent of the total. The largest agricultural source of phosphorus is cropland (conventional tillage, conservation tillage, hay). In order of magnitude of total phosphorus loads delivered are loads from cropland, point sources, animal wastes, urban areas, pasture land, and forest land.

Total nitrogen per unit loads and the proportion that is subsurface are listed in Table 3. Nitrogen



Total bar values are edge of stream loads.
Shaded areas of bar are delivered loads.

Figure 3. Edge of stream and delivered TP loads.

losses due to attenuation are listed in Table 4.

Agriculture is the predominate source of nitrogen delivered to the Potomac. Agricultural nitrogen accounts for 40 percent of the total nitrogen load. The largest agricultural source of nitrogen is cropland (conventional tillage, conservation tillage, and hay). In order of magnitude, the total nitrogen delivered to the water comes from the following sources: point sources, cropland, forest land, urban areas, pasture land, animal wastes, and atmospheric deposition.

Figures 5 and 6 show the total phosphorus and nitrogen loads, relative to the Bay Agreement and the loads expected under a limit of technology scenario. The Bay Agreement loads are defined as a 40 percent reduction in controllable loads. Controllable loads are defined as everything over and above the total phosphorus or total nitrogen loads that would have come from an entirely forested watershed.

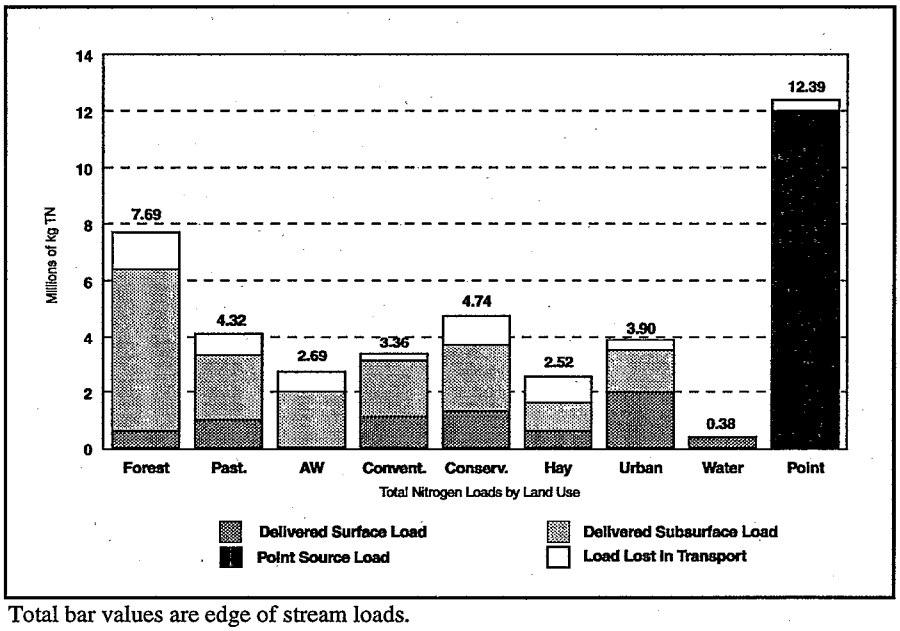
Point source loads are considered, in this definition, to be entirely controllable. The actual Bay Agreement loads are based on a reduction of *basin* controllable loads by 40 percent—the presentation of controllable loads by land use is merely for comparison. As Figures 5 and 6 illustrate, some load types, such as animal waste, point source, and cropland are more easily controlled than others. The limit of technology loads are defined as: all cropland in conservation tillage; the Conservation Reserve Program fully implemented; nutrient management, animal waste controls, and pasture stabilization systems implemented where needed; a 20 percent reduction in urban loads; and point source effluent controlled to a level of 0.075 mg/l total phosphorus and 3.0 mg/l total nitrogen.

Conclusion

The Potomac HSPF model is a successful water quality simu-

Table 2. Phosphorus transport loss by model segment. Negative loss indicates in-stream processes such as scour are generating loads in addition to the loads delivered to the river reach from point and nonpoint sources.

Geographic Region	Segment	Mean (range) Model Seg. Loss	Mean (range) Total Trans. Loss
Appalachian	160	6% (2% - 13%)	24% (13% - 40%)
	170	-26% (-90% - 13%)	-2% (-75% - 35%)
	175	3% (-1% - 8%)	19% (8% - 25%)
	190	13% (-3% - 32%)	29% (12% - 50%)
	200	13% (11% - 21%)	18%(15% - 27%)
Piedmont	180	11% (7% - 19%)	16% (12% - 25%)
	210	10% (5% - 13%)	15% (10% - 17%)
	220	6% (5% - 8%)	6% (5% - 8%)
Coastal Plain	530	0%	0%
	540	0%	0%
	550	0%	0%



Total bar values are edge of stream loads.
Shaded areas of bar are delivered loads.

Figure 4. Edge of stream and delivered TN loads.

Table 3. Potomac unit area average total nitrogen loads by land use

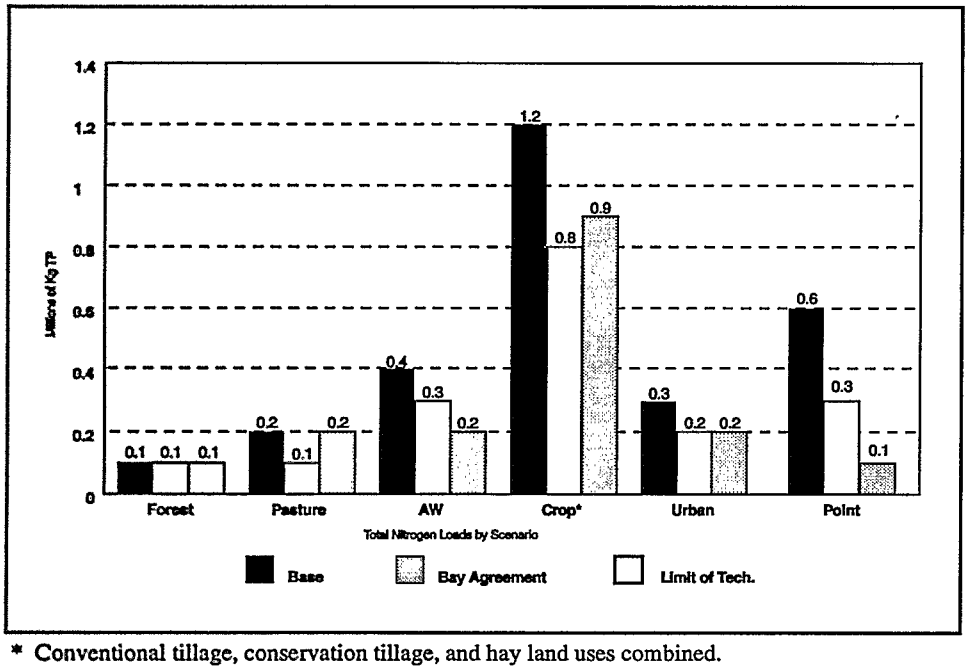
Land Use	Unit Area Load (kg/ha)	Proportion of Load Subsurface (%)
forest	3.67	82
pasture	8.28	63
animal waste	2120.00	0
conventional till	26.84	56
conservation till	20.74	62
hay	9.10	55
urban	10.56	63
atmospheric loads[a]	16.61	0

[a]Loads directly to water surfaces.

Table 4. Nitrogen transport loss by model segment

Geographic Region	Segment	Mean (range) Model Seg. Loss	Mean (range) Total Trans. Loss
Appalachian	160	8% (7% - 9%)	24% (19% - 29%)
	170	7% (5% - 9%)	23% (19% - 29%)
	175	3% (3% - 4%)	17% (15% - 21%)
	190	20% (17% - 29%)	33% (29% - 44%)
	200	12% (9% - 16%)	16% (12% - 19%)
Piedmont	180	10% (7% - 12%)	15% (11% - 17%)
	210	10% (7% - 13%)	15% (11% - 18%)
	220	5% (4% - 6%)	5% (4% - 6%)
Coastal Plain	530	0%	0%
	540	0%	0%
	550	0%	0%

lation that quantifies the nonpoint source and point source nutrient loads from all basin sources. The model was essential in establishing a consistent method of accounting for the nutrient loads, among all sources, the basin jurisdictions of four states, and the District of Columbia. The model is used to examine the level of control achievable from different management practices. The model has examined management practices, that when combined into strategies of nutrient control, will meet the Chesapeake Bay Program water quality objective of a 40 percent reduction in controllable nutrients in the Potomac basin, and will do so in a cost-effective and equitable manner.



* Conventional tillage, conservation tillage, and hay land uses combined.

Figure 5. Potomac TP loads by scenario.

Acknowledgments

The authors wish to acknowledge the state, regional, and federal members of the Chesapeake Bay Program Modeling Subcommittee for their essential guidance and direction throughout the development of the Chesapeake Bay Watershed Model, of which the Potomac HSPF Model is only a small part.

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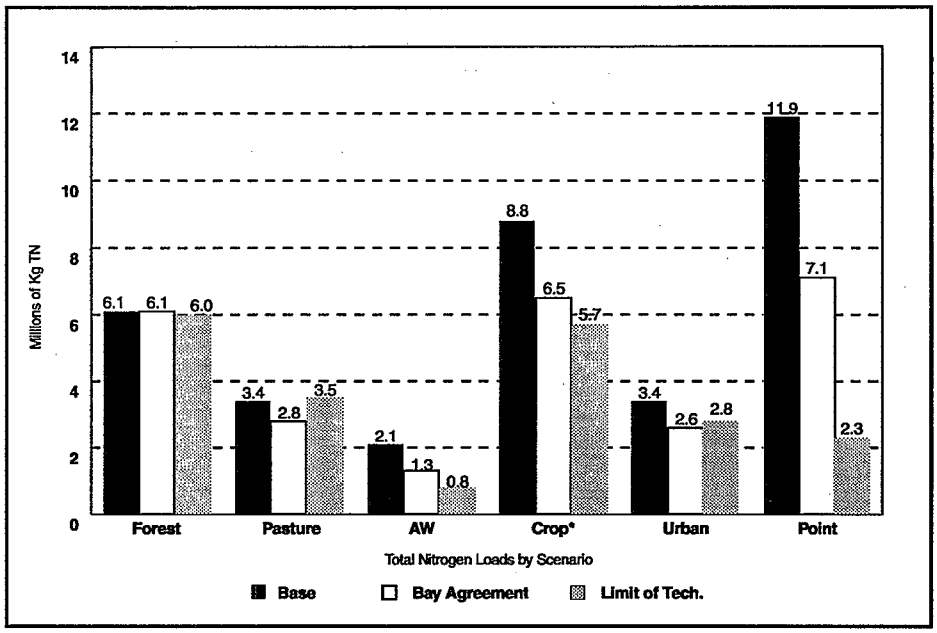

* Conventional tillage, conservation tillage, and hay land uses combined.

Figure 6. Potomac TN loads by scenario.

Characterizing Pollution Sources in Coastal Watersheds: NOAA's National Coastal Pollutant Discharge Inventory Program

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Characterizing pollution sources—identifying the sources, determining their location, inventorying their important operational parameters, and estimating the type, quantity, and timing of pollutants discharged—is a basic requirement for developing an integrated watershed management capability. Without this information, it is not possible to assess the relative contributions from various sources, and, in turn, determine which management actions will provide the desired environmental improvements at the least cost to society.

Source characterization can be undertaken, and is needed, at different time and space scales depending on the scale and scope of the watershed management issues being addressed. For the last 10 years, the National Oceanic and Atmospheric Administration (NOAA) has been developing and refining its capabilities to characterize pollution sources located in the Nation's coastal watersheds as part of its National Coastal Pollutant Discharge Inventory (NCPDI) Program. The information developed through this program is national in scale and intended for strategic assessments—characterizations that focus on the Nation as a whole or on large coastal and oceanic regions. The analyses made using information from the NCPDI program are intended to complement, not replace, the more detailed "tactical" analyses of coastal resource use conflicts in specific areas and often can point the direction for the tactical analyses (Ehler and Basta, 1984).

The centerpiece of the NCPDI program is a master data base containing seasonal and annual discharge estimates for 15 pollutant parameters. Estimates are made for all point and nonpoint sources discharging to surface waters in coastal areas, and these estimates can be aggregated by county or watershed. Estimates are also made for the pollutant load carried into the coastal watersheds from upstream areas. Most of the discharge estimates in the data base are made using engineering models because of the difficulty in obtaining monitored data for many of the pollutant parameters. The main features of the NCPDI data base are summarized in Tables 1 and 2.

In addition to building and maintaining the master data base, over the last several years the NCPDI Program has undertaken several other major projects related to pollution characterization in coastal watersheds. These include:

- A national assessment of the distribution of 12 indicators of nonpoint source pollution potential in over 300 watersheds that drain to the Nation's coastal waters. This assessment was conducted to support the coastal zone boundary review requirements of section 6217 of the Coastal Zone Act Reauthorization Amendments (CZARA) (Coastal Nonpoint Source Control Program) (Strategic Environmental Assessments

Table 1. Pollutants included in the NCPDI master data base

Pollutants	Description	Annual Units
Flow	Wastewater discharge from point source. Flow can be process, cooling, sanitary, storm, other, or a combination of any of these	Million gallons
BOD	Biochemical Oxygen Demand (BOD5); measure of organic material that can be readily oxidized through microbial degradation	Pounds
TSS	Total Suspended Solids; measure of suspended solid material	Pounds
Total Nitrogen[a]	Measure of all forms of nitrogen including nitrate, ammonia, and organic forms	Pounds
Total Phosphorus	Measure of all forms of phosphorus, i.e., ortho and para compounds	Pounds
Oil and Grease	A mixture of hydrocarbons found in petroleum comprised of hundreds of chemical compounds	Pounds
Heavy Metals Arsenic Cadmium Chromium Copper Iron Lead Mercury Zinc	A group of elements present in the environment from natural and anthropogenic sources that can produce toxic effects; determination based on EPA standard methods that measure environmentally available metals	Pounds
FCB	Fecal Coliform Bacteria. FCBs are used as an indicator of the presence of pathogens	Cells

[a] When updated, the data base will contain information on the discharges of ammonia, Kjeldahl nitrogen, nitrate, and nitrite where facilities monitored for these forms of nitrogen.

Table 2. Major pollutant discharge source categories in the NCPDI

1. Point Sources
   - Wastewater Treatment Plants
   - Direct Industrial Dischargers
   - Power Plants
   - Water Supply Treatment Plants
2. Urban Nonpoint Sources
   - Separate Sewered Areas
   - Combined Sewered Areas
3. Nonurban Nonpoint Sources
   - Cropland
   - Range and Pastureland
   - Forestland
4. Pollutants in Streamflow entering the Coastal Zone

Division and Coastal Programs Division, 1992).

- A survey of the number, severity, and causes of reported fish kills in coastal rivers and estuaries from 1980 through 1989 (Lowe et al., 1991).
- An assessment of the agricultural use and the impact on estuarine organisms of 35 important pesticides in the 102 estuarine drainage areas in NOAA's National Estuarine Inventory (Pait et al., 1992). Figure 1 shows a national view of pesticide usage adjusted for aquatic hazard potential.

Updating the NCPDI—Making It Better

The discharge inventory is currently being updated to a base period of 1990-1992 (using data collected for 1991 whenever possible). When completed in mid-1994, the data base will contain discharge estimates for urban and nonurban nonpoint source pollution in over 300 coastal watersheds, 3,500 major and 24,000 minor point sources, and loadings carried in the streamflow of over 100 major rivers and streams entering coastal watersheds.

Prior to beginning the update, the NCPDI team considered ways to improve the information content and utility of the data base. Part of this analysis involved identifying the features of the ideal source characterization data base (Table 3). After reviewing this list and considering the realities of data quality, consistency, and availability and the limits on the resources available to make improvements, the team focused on improving the data base in the following areas:

- *Updating all coastal regions at the same time.* In the past, the East Coast, Gulf of Mexico Coast, and West Coast components were developed separately. Because it took 12 to 24 months to complete an inventory for all sources for a component, the base years for each component were different, making comparisons across components difficult to interpret.
- *Defining levels of data refinement.* By giving priority to a nationally consistent and timely base year, some detail and refinement in the information content of the data base is sacrificed. To address this trade-off between timeliness and detail, the

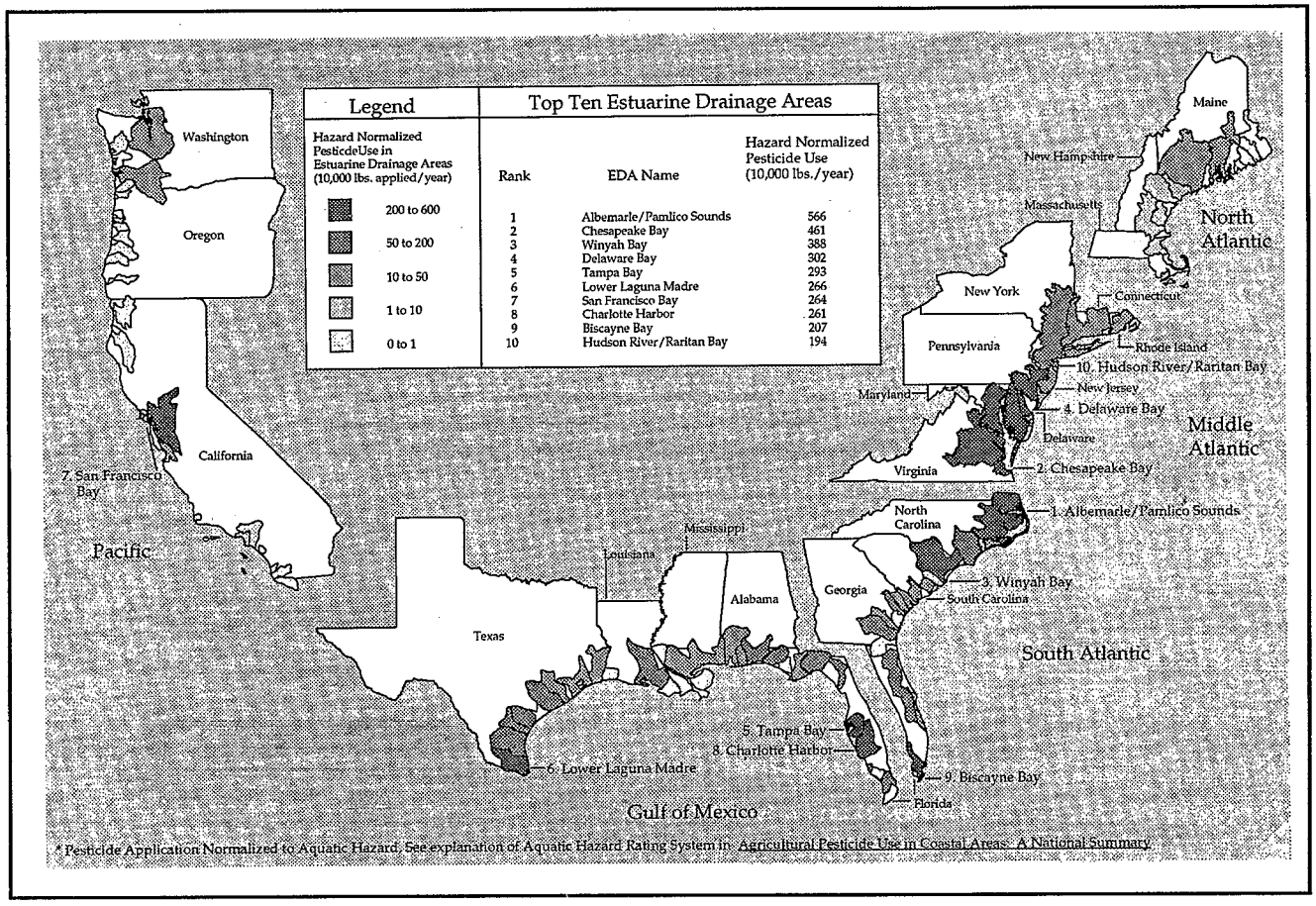

Figure 1. Estimated use of 35 agricultural pesticides in estuarine drainage areas normalized for aquatic hazard potential, circa 1987.

team has adopted a data base development model that describes three levels of inventory information.

LEVEL ONE data will be based on information obtained from readily available national and state information sources. Missing values for critical data fields will be inferred based on a hierarchy of surrogate data sources. For example, missing latitude/longitude information for a minor wastewater treatment plant will be filled first by using the centroid of the ZIP code area for the facility. If that information is not available, the centroid of the city in which the facility is located will be used. Data will be quality controlled by filtering out obviously erroneous values and values that are outside an acceptable range. Discharge estimates will be based on typical engineering values where monitored or permit data are not available. LEVEL ONE data will be the standard for information in the national master data base.

LEVEL TWO data will use state and local data sources to refine level one

Table 3. Some features of an ideal characterization data base

- All important sources included
- Pollutants of interest included
- Sources spatially referenced by political and hydrologic units
- Discharges estimated over time (daily, monthly, seasonal, etc.)
- Estimates reported as a range (variability considered)
- Quality of each estimate described (relative accuracy assessed)
- Audit trail indicating source and basis of estimate included
- Methods clearly documented
- Factors that influence discharges inventoried
- Anthropogenic versus natural inputs distinguished
- Management scenarios can be tested
- Links to economic analysis (cost functions, etc.)
- Links to transport and fate/effects models
- Estimates are compared and avlidated against monitored data and or estimates from other models
- Limitations clearly stated
- Periodic updates that allow for trend analysis
- Easy to access, analyze, extract, and map information

estimates. Portions of the LEVEL ONE estimation methods will be improved, and in some cases, more sophisticated models will be substituted. LEVEL TWO data will be generated only as resources allow or external demands dictate and will probably only be compiled for specific regions.

LEVEL THREE data will incorporate information from special studies designed to provide data to improve the accuracy and reliability of the source characterization. As with LEVEL TWO data, LEVEL THREE data will be generated only as resources allow or external demands dictate. LEVEL THREE estimates may only be made as a demonstration project for a single watershed because of the time and resource costs involved.

- *Expanding the NCPDI study area.* The new study area will be expanded to include the 359 U.S. Geological Survey hydrologic cataloging units contained in the coastal watershed portion of NOAA's Coastal Assessment Framework (CAF) (Figure 2). The CAF, which is being used by other components of NOAA's Strategic Assessment Program, will provide a consistent spatial framework within which information characterizing coastal resource use can be analyzed and compared. Figure 2 shows the new national study area.
- *Adding Great Lakes point source estimates.* For the first time, the NCPDI data base will contain information for point sources in coastal watersheds draining to the Great Lakes. At this time, no estimates for nonpoint sources are planned for the Great Lakes.
- *Carrying more information for point sources.* The background files of the point source component of the

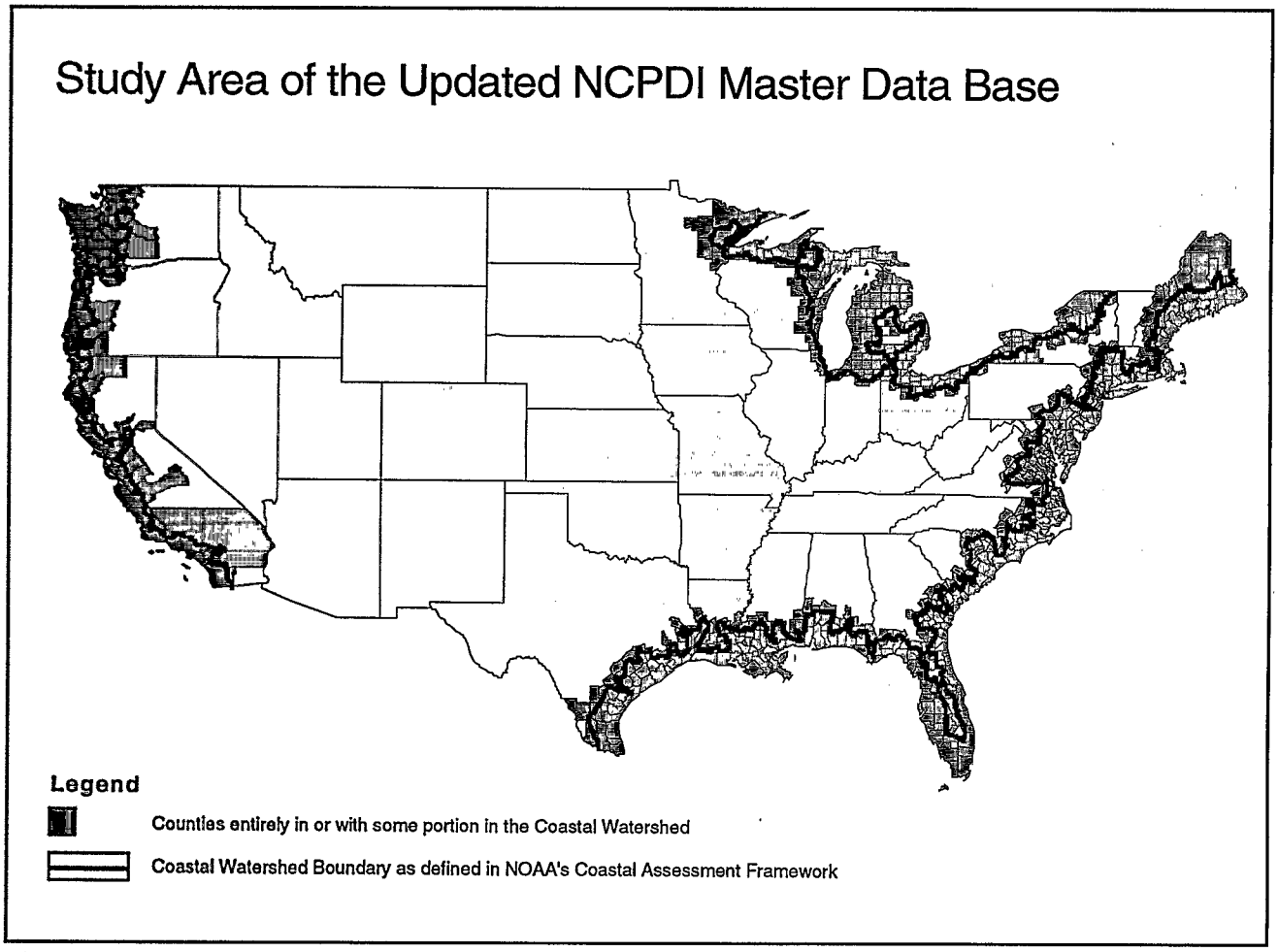

Figure 2. The revised NCPDI study area is based on NOAA's Coastal Assessment Framework.

NCPDI data base will contain permit limits and discharge estimates for the over 1,600 pollutant parameters reported in the U. S. Environmental Protection Agency's (EPA) Permit Compliance System. This information can be used to identify the number and type of facilities discharging a specific pollutant in different watersheds and compare levels of discharge and permitting across watersheds.

- *Improving the audit trail.* The NCPDI audit trail is the series of codes and supporting files that document the data source(s) and basis used to make each discharge estimate. These codes allow the user to understand the derivation of each estimate, and evaluate the relative reliability of the information used in a particular analysis. The number of variables for which this information is carried will be significantly increased in this update.
- *Refining estimates for nitrogen.* The NCPDI will contain estimates for 15 pollutant parameters. However, as part of the update, estimates will be made for several important forms in addition to total nitrogen. These include ammonia, Kjeldahl inorganic, nitrites, and nitrates. This added focus reflects the belief that nutrient discharges remain a major cause of the water quality problems reported in estuarine and coastal waters.
- *Improving estimation methods.* The new estimates will incorporate improvements that have been made in the estimation techniques used for urban and nonurban nonpoint sources.
- *Improving access and mapping/ geographic information system (GIS) support.* When the entire data base update is completed in 1994, a summarized version will be included in a centralized Strategic Environmental Assessments (SEA) Division data base. Users will be able to access and download the data from this data base using a dial-in network. In addition, some portions of the data base that are appropriate for geographic display, such as locations of point sources, will be available through NOAA's GeoCoast GIS lab. Finally, summarized versions of the data will be included in several of the desktop decision support systems such as the Coastal Ocean Management, Planning, and Assessment System that the Strategic Environmental Assessments Division has developed.

Using the NCPDI to Better Manage Coastal Watersheds

When the NCPDI Program was begun in the early 1980s, a primary focus for the information developed by the Program was to support analyses of national policy issues related to coastal and ocean resource use conflicts. At that time, issues such as whether to grant 301(h) waivers (waivers of secondary treatment for municipal treatment plants discharging to the ocean) and whether to allow ocean dumping of sewage sludge were being debated. It was felt that information that allowed managers to compare the discharge characteristics, costs, and benefits of alternative management strategies across coastal regions would improve the quality of the decision making.

Information from the NCPDI Program has been and can continue to be used for national analyses. Two relatively recent examples are for the assessment of the susceptibility of the Nation's estuaries to nutrient discharges (Quinn et al., 1991), and the assessment of coastal zone boundaries related to implementation of section 6217 of CZARA. However, we are shifting the Program focus to more regional and state-level uses in response to our own and others (e.g., Malone, 1992) growing recognition that regional-scale analyses are the optimal level at which to effectively address large scale coastal resource use conflicts.

As a result, in the future, the thrust of our work will be in two areas—producing source characterizations for regional and state-level assessments and developing information to meet specific needs of programs that address coastal resource management problems.

Two examples of the first focus are the regional watershed characterizations of point source discharges currently underway for the Gulf of Maine Program and for the Virginian Province component of EPA's Environmental Monitoring and Assessment

Program. Several watershed-scale source characterization studies that have been proposed for the Gulf of Mexico Program could also be undertaken with information from the NCPDI Program.

Possible program-specific applications include source characterizations to support the development of Coastal Nonpoint Source Control Programs—section 6217 of the CZARA; site evaluations for potential Marine Sanctuary designations; total maximum daily load studies—section 303(d) of the Clean Water Act (CWA); EPA's biennial National Water Quality Inventory—section 305 (b) of the CWA; and EPA's National Estuary Program and Near Coastal Waters projects.

The NCPDI information can also be used to provide a baseline data set of sources and discharges for states that do not have an existing comprehensive inventory; as an alternative source of estimates for comparison with regional, state, and basin level inventories; and for international assessments comparing discharges from land-based sources in the United States to those of other nations (e.g., the United Nations Environmental Programme's (UNEP's) Caribbean Environment Programme).

There are a variety of ongoing and potential uses for the source characterization information developed by the NCPDI Program. However, it is important to recognize the limitations. The development of national and regional source characterization data bases requires that information be compiled and synthesized from a wide variety of sources. Estimates must often be based on assumptions and typical values. As a result, potential users may question the credibility and utility of the information. This questioning is absolutely essential to ensure proper use of the data. No user should accept the estimates at face value but rather must expend time and effort to understand clearly how the estimates are made and the biases they contain (Basta et al., 1985). The NCPDI team is committed to working with all users to help them gain this understanding for the NCPDI data sets. It is only after understanding the limitations of the data that the information can be appropriately applied to improve coastal watershed management decisions.

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River Restoration Utilizing Natural Stability Concepts

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The rivers of this country have been under siege in the last 75 years. They have been straightened, raised, lowered, lined, narrowed, widened, diverted, and dammed. Their floodplains have been taken over for the good of those who settled the land. Houses and even cities have been located where the high flows of the river were naturally dissipated amongst dense stands of riparian vegetation and associated wildlife habitat.

Well-intended, but misguided efforts toward river control are now starting to show the adverse results of such works. Those who live along the channelized river with the high levees have been watching the elevation of the river bed become higher than the floodplain. As this process occurs, the levees have to be raised to keep up with the rising river. When the stream wants to again seek its historic curves, erosion and breach of the levees occur. When flood waters breach through from an elevated river bed the great velocities and depths of flow create more damage than would have occurred naturally.

Concrete has not added to the aquatic and terrestrial habitats or to the beauty of the river. Engineers were directed to establish expertise at designing trapezoidal, lined, and straightened channels as the people demanded protection from the river. Rather than zoning for certain uses in the floodplain and along the river fringe, the direction has been to control and contain the river.

We are slowly learning from our recent observations and the unfortunate fate of those who are the recipients of the river's wrath. The saying "it's not nice to fool Mother Nature" seems particularly appropriate as we see the river trying to re-establish its natural functioning and pattern. There has recently been a rejuvenation of thought and direction by many throughout the country about the restoration and protection of our rivers. One can observe the loss of habitat, river function, and beauty for only so long before an ethical, as well as a geomorphic, threshold is exceeded.

When an agency such as the U.S. Army Corps of Engineers (COE) begins researching ways of "putting a river back" and integrating environmental engineering into its planning efforts, then indeed, there is a tide of change in the country! Engineers and others are faced with a new challenge—"How do you put a river back?" The traditional control and containment designs don't cover this. In recent years, the author has been working with federal, state, and local agencies, as well as consultant firms to teach and include the application of river restoration principles into their design manuals and procedures.

Can we live in harmony with the river without causing these adverse adjustments? Can we continue to utilize the resources provided by the river without jeopardizing the integrity of the river? The answer is yes! But to do so, we must understand the "rules of the river." We still have many positive examples where we have lived in harmony with the river. In many of these instances, well-managed land use activities adapted to infrequent flooding have contributed to the livelihood of many without adverse affects on the river. In some urban areas, floodplains are maintained in vegetated parks with trails interspersed. When floods occur, as they always will, there is little damage.

General Principles

Channel Variables

Underlying the complexities of river processes is an assortment of interrelated variables that determine the dimension, pattern, and profile of the present-day river. The resulting physical appearance and character of the river are products of channel boundary and slope adjustment to the present streamflow and sediment regime.

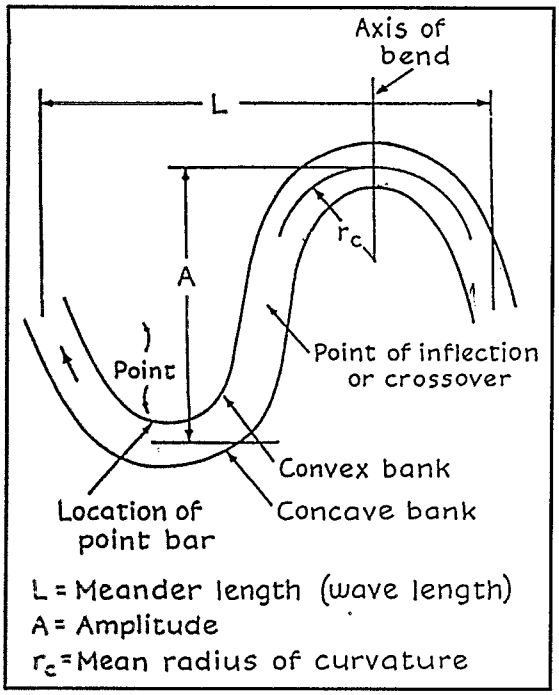


Figure 1. Plan-view sketch of idealized meander (from Leopold et al., 1964).

River form and fluvial processes evolve simultaneously and operate through mutual adjustments toward self-stabilization. Stream systems are dynamic and their pattern, dimension, and profile are determined by an interaction of process variables, such that a change in one variable sets up a mutual adjustment in the others (Leopold et al., 1964). The variables are width, depth, slope, velocity, flow resistance, sediment size, sediment load, and stream discharge. Because of the complex interactions associated with the individual variables, a stream classification system was developed to describe combinations of the various "integrations" as predictable, morphological stream types (Rosgen, 1985, 1993). The stream classification system is useful in restoration designs to quantify the basic morphological relations for a given river so that the design may better match the potential of the natural, stable channel form.

Successful restoration efforts must utilize established principles of process and function that accommodate a river's predictable response tendencies. Channel stabilization methods that do not follow the known and observable relations are inviting potential long-term problems due to the negative feedback mechanisms from the very streams that we are trying to "help." The basic tendencies of river function and adjustment rely on principles reported by Inglis (1947), Leopold and Wolman (1957, 1960), Leopold et al. (1964), and Langbein and Leopold (1966). The relationship of: meander geometry related to stream size; stream size related to stream discharge; the linear sequence of riffle-pool bed features related to channel width; and hydraulic geometry relations were established by this early research and are used today as the theoretical basis for the restoration design.

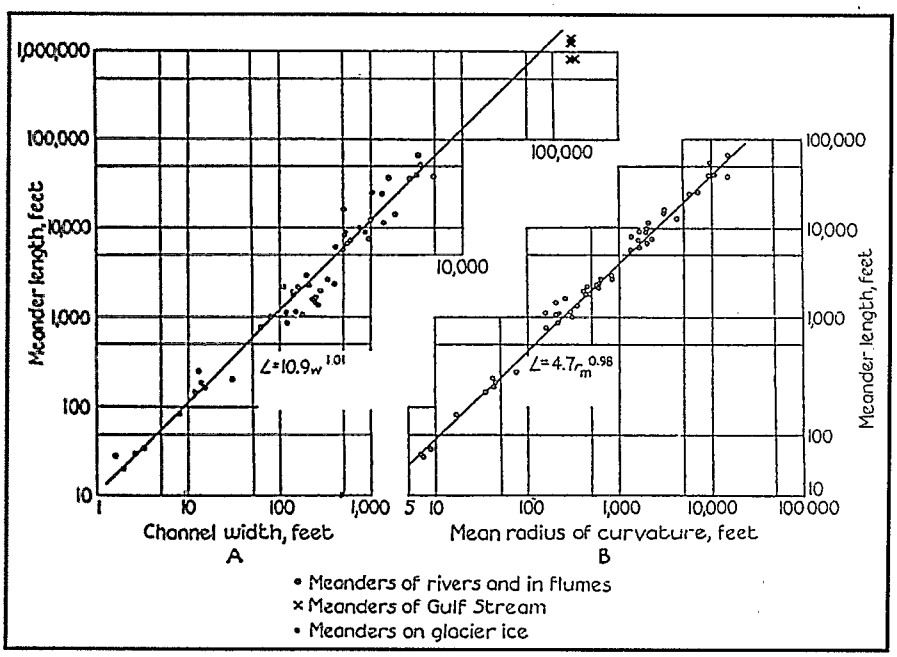


Figure 2. Relation of meander length to width (A) and to radius of curvature in channels (from Leopold et al., 1964).

Specific characteristics of meander geometry are related to channel dimensions and plan features such as meander wave length, radius of curvature, and meander amplitude as described and presented in Figures 1 and 2. The Leopold and Wolman (1960) equations that represent these relations are shown as:

$$L_m = 10.9W^{1.01} \quad (1)$$

$$A = 2.7W^{1.1} \quad (2)$$

$$L_m = 4.7\, r_c^{0.98} \quad (3)$$

where: L_m = meander length (ft)
W = bankfull surface width (ft)
A = amplitude (ft)
r_c = mean radius of curvature (ft)

(Equations published in English units.)

Another useful equation developed by Langbein and Leopold (1966) was that of a sine-generated curve which described meander paths:

$$R_c = \frac{L_m K^{1.5}}{13 (K-1)^{0.5}} \quad (4)$$

where: K = channel sinuosity (channel length/valley length)
R_c = radius of bend curvature.

A recent study by Williams (1986) tested the above equations on a data set larger than was used in the original work. Williams found that the application of the equations produced results that agreed quite well with the earlier findings of Wolman and Leopold (1957, 1960), (Figure 3).

A common problem associated with the "traditional designed channel" restoration is that attempts are made to put all of the flow into *one* channel. Most alluvial rivers consist of *three* distinct, but related, channels: the thalweg, or low flow channel; the bankfull, or normal high water channel; and the established floodplain, or channel that carries flows greater than the bankfull discharge. In many river restoration designs, this very basic and important concept is not taken into consideration (Figure 4). As a result, channels designed to contain all the flows in a common width, are constructed "over-width." The consequence of building these over-width channels often leads to aggradation due to a reduction in stream energy or competence of the river necessary to move the sediment associated with the normal, frequent runoff events. Once sediment deposition occurs and bar features form, infrequent flushing flows do not remove these features but start an aggradation process and lateral migration adjustment. Over time, bar features enlarge, extend, and often become islands. This process is more prevalent in the riffle/pool stream types rather than the step/pool types.

Often when grade control structures, such as check dams, are installed in rivers, the local upstream slope is reduced. The width/depth ratio increases, and the stream responds by initiating lateral adjustment. A study of aerial photographs over large areas will show that channel sinuosity is higher on the gentle gradient rivers than the steeper channels. The higher sinuosity occurs as a

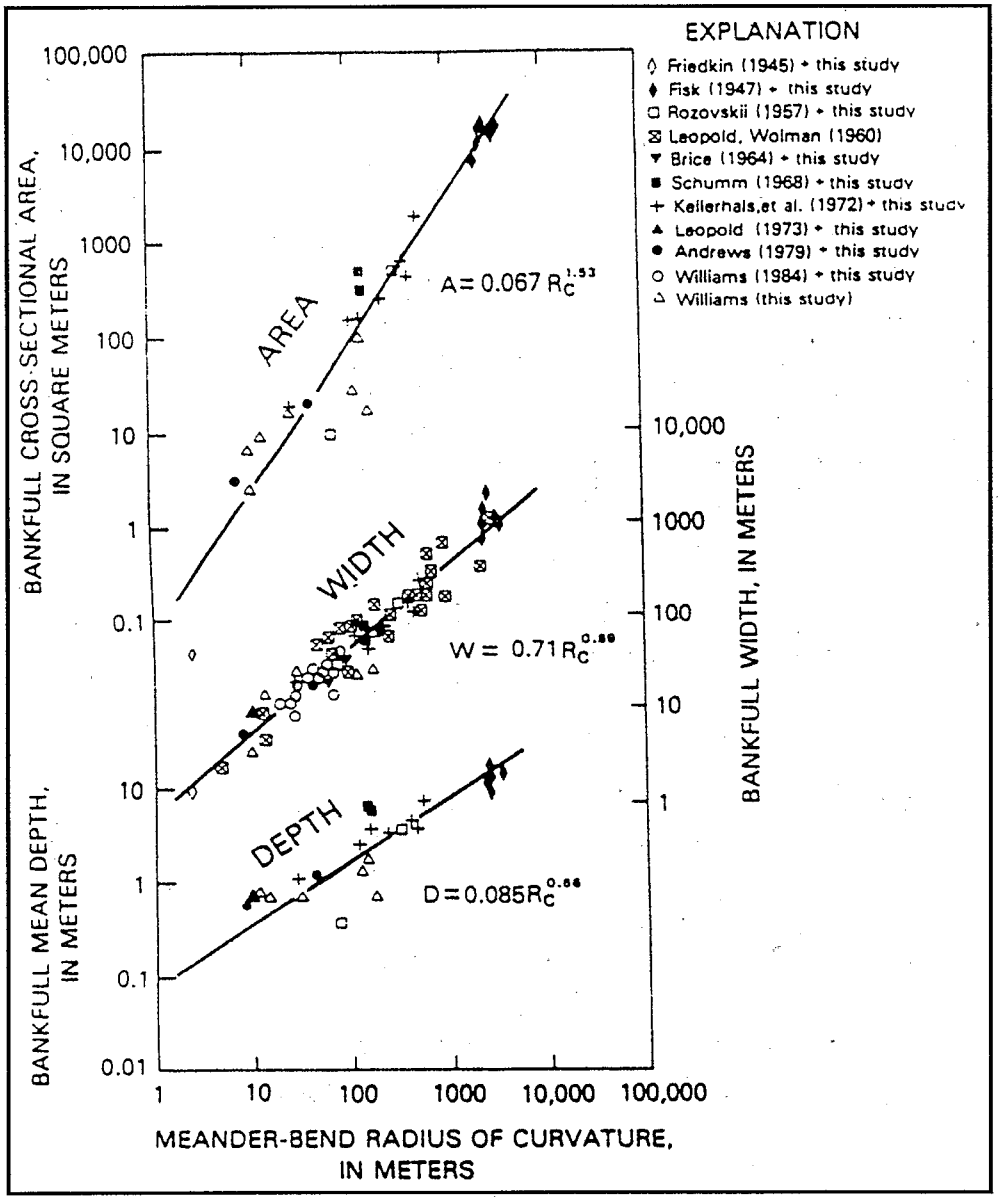


Figure 3. Relation of channel dimensions to meander-bend radius of curvature in meters (from Williams, 1986).

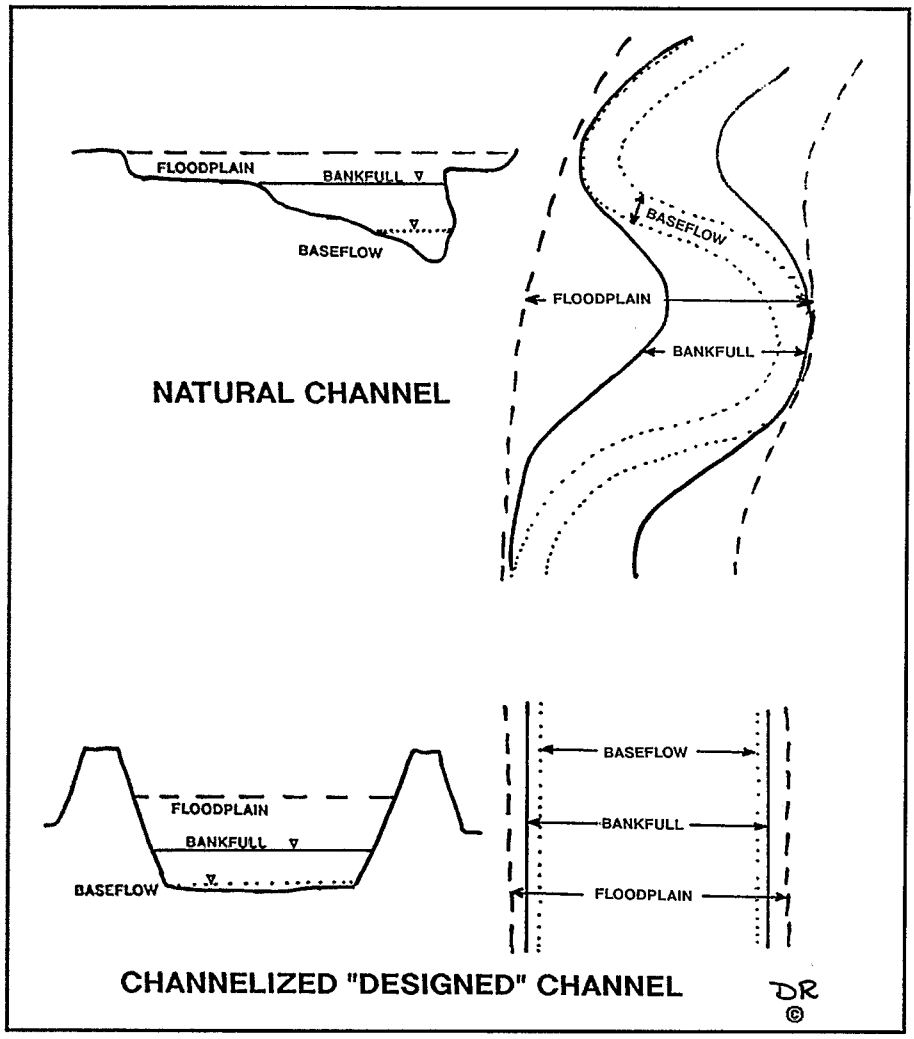


Figure 4. Comparison of "designed" channel dimension and pattern compared to natural channel.

result of natural bank erosion processes as the river, in an effort to accommodate excess stream energy, naturally adjusts it's form and planimetric configuration. Flattening slopes of rivers, which is often a part of stream restoration projects, usually results in accelerated bank erosion and sediment deposition.

Stream Classification

An arrangement of the morphological variables that can be organized into a common description called "stream types" are shown in Figures 5 and 6. Applications for restoration involve the integration of the variables as stream types into more detailed descriptions involving plan features of the most probable state. An example of this is shown in the meander width ratio relations by stream type (Figure 7).

In river restoration design, the meander width ratio is an important morphological feature that must be integrated into the restoration plan. Sinuosity, width/depth ratio, entrenchment ratio, slope, and particle size distribution are not only important for delineation of stream types, but are critical for design specifications for a given river morphology.

Evolution of stream types, caused either naturally due to climate changes or induced due to changes in watershed management, can be observed as a sequential series of channel change. An example of one scenario for a series of channel adjustments and corresponding change in stream type is depicted in Figure 8. Knowing the current state and direction or tendency of channel adjustment is critical to river restoration design. We often try to make a stream into what it "doesn't want to be"! The potential state, or condition, can be inferred by stream type as well as empirical relations for design specifications to emulate the stable morphology.

Watershed Conditions

Before entering into a major stream restoration project, it is important to *first* understand what caused the instability. Often restoration work is only an exercise in *patching symptoms* rather than working toward a *cure*! Flow regimes that can be altered in magnitude and duration due to vegetation manipulation, urban development, etc. have to be understood and calculated. Changes in sediment supply directly affect the channel stability, and as such need to be determined. Taking care of the problem on-site rather than accommodating sediment supply through in-channel storage is a recommended alternative. However, as logical as this statement appears, there are many ill-fated projects being constructed that are designed to store excess sediment in the active channel.

Structural alternatives can often be minimized or even eliminated if a healthy

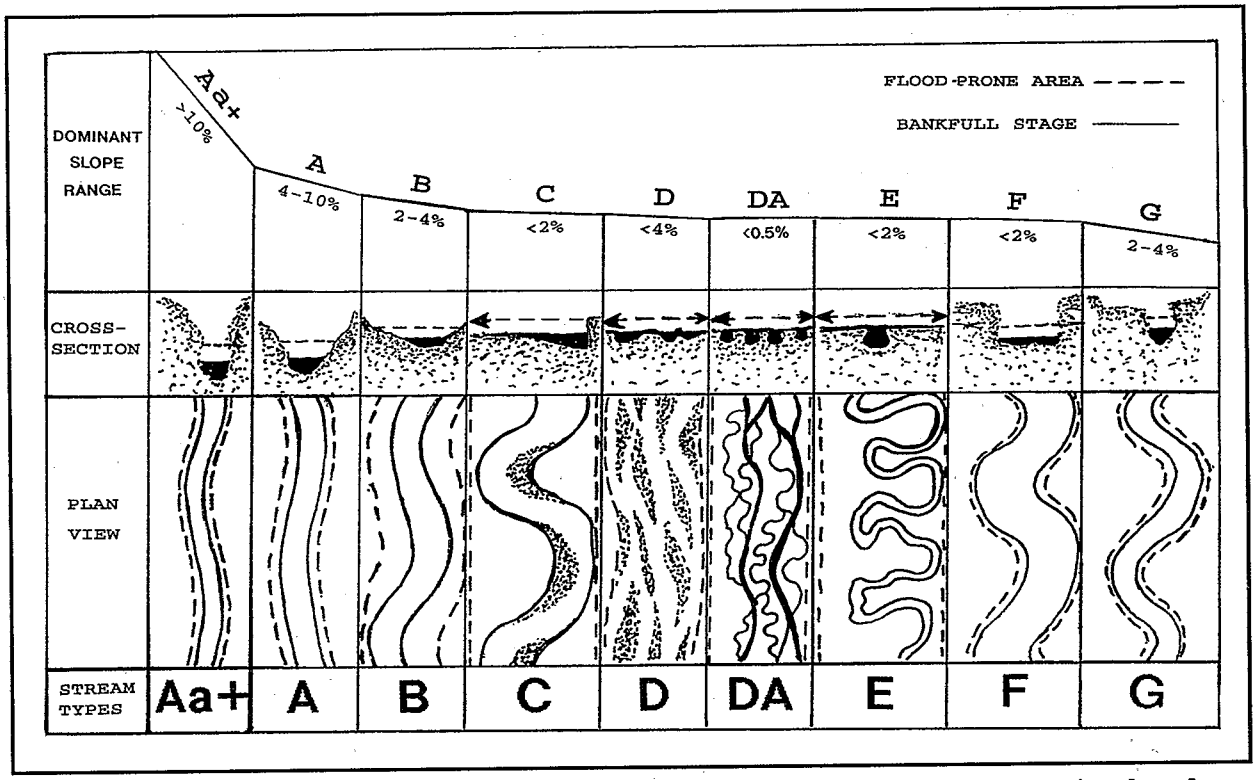
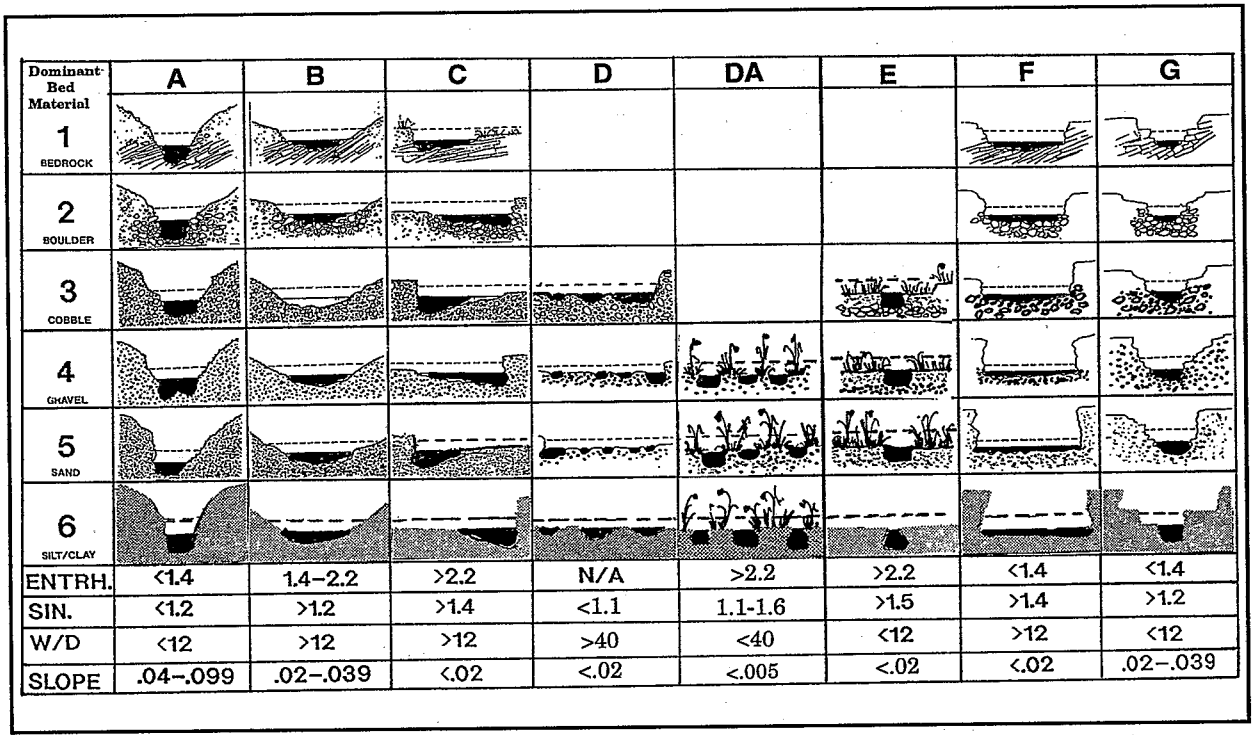


Figure 5. Broad level stream classification delineation showing longitudinal, cross-sectional, and plan views of major stream types (from Rosgen, in review, 1993).



	A	B	C	D	DA	E	F	G
ENTRH.	<1.4	1.4–2.2	>2.2	N/A	>2.2	>2.2	<1.4	<1.4
SIN.	<1.2	>1.2	>1.4	<1.1	1.1-1.6	>1.5	>1.4	>1.2
W/D	<12	>12	>12	>40	<40	<12	>12	<12
SLOPE	.04–.099	.02–.039	<.02	<.02	<.005	<.02	<.02	.02–.039

Figure 6. Illustrative guide showing cross-sectional configuration, composition, and delineative criteria of major stream types (from Rosgen, in review, 1993).

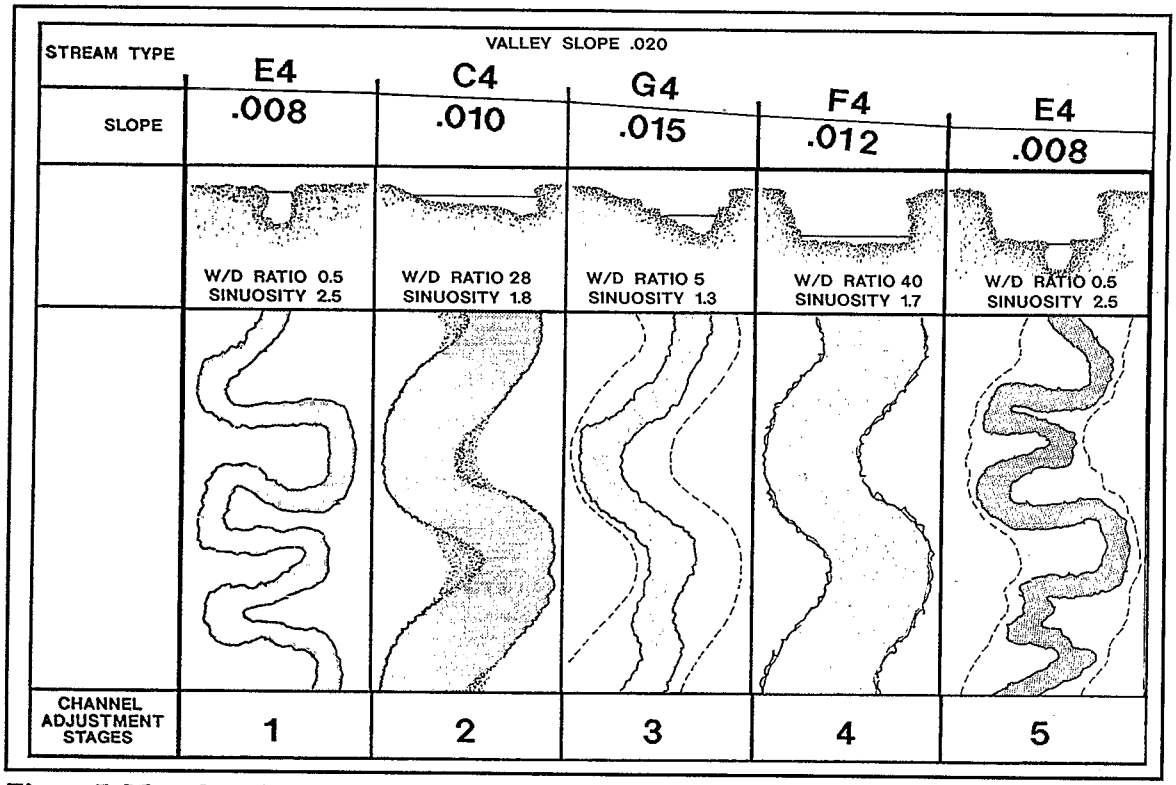


Figure 7. Meander width ratio (belt width/bankfull width) by stream type categories (from Rosgen, in review, 1993).

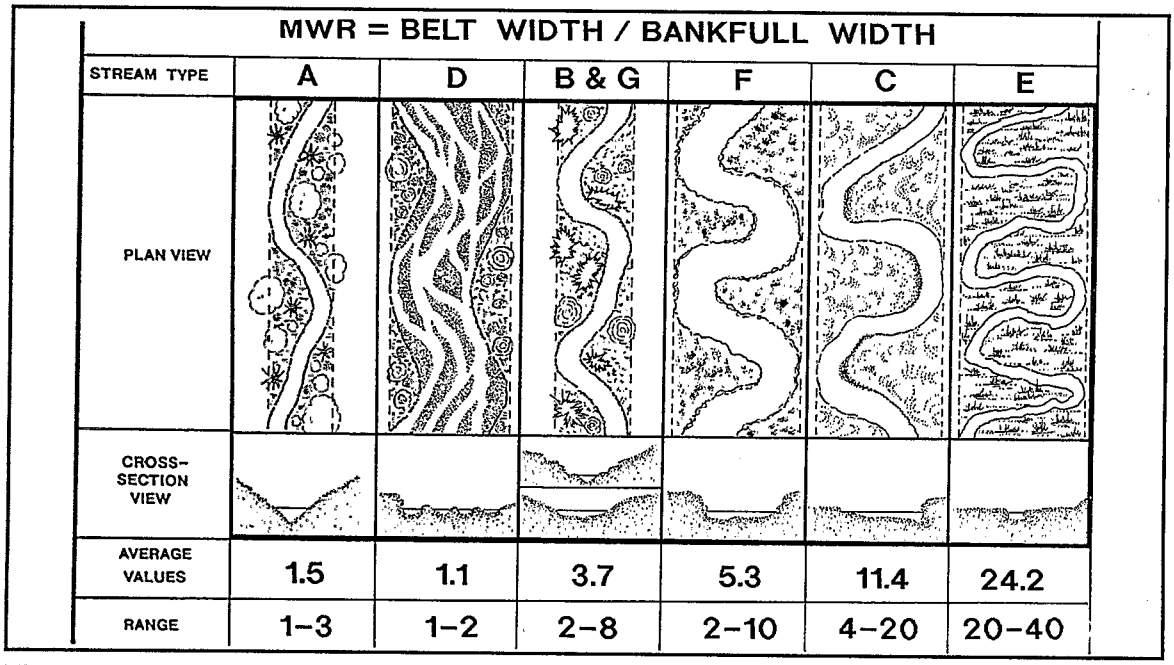


Figure 8. Evolutionary stages of channel adjustment showing corresponding changes in morphology, dimensions, pattern, and slope as indicated by stream type (from Rosgen, in review, 1993).

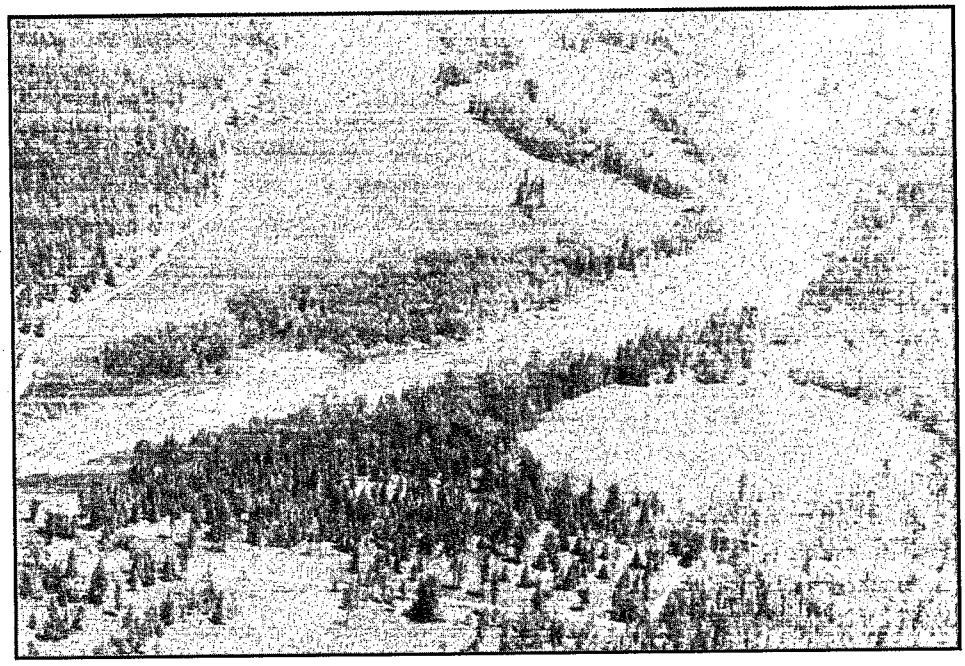
watershed condition can be maintained. *Good* riparian grazing practices can be very effective at reducing bank erosion and improving fish habitat. Fair to poor grazing practices can reverse this process.

Examples

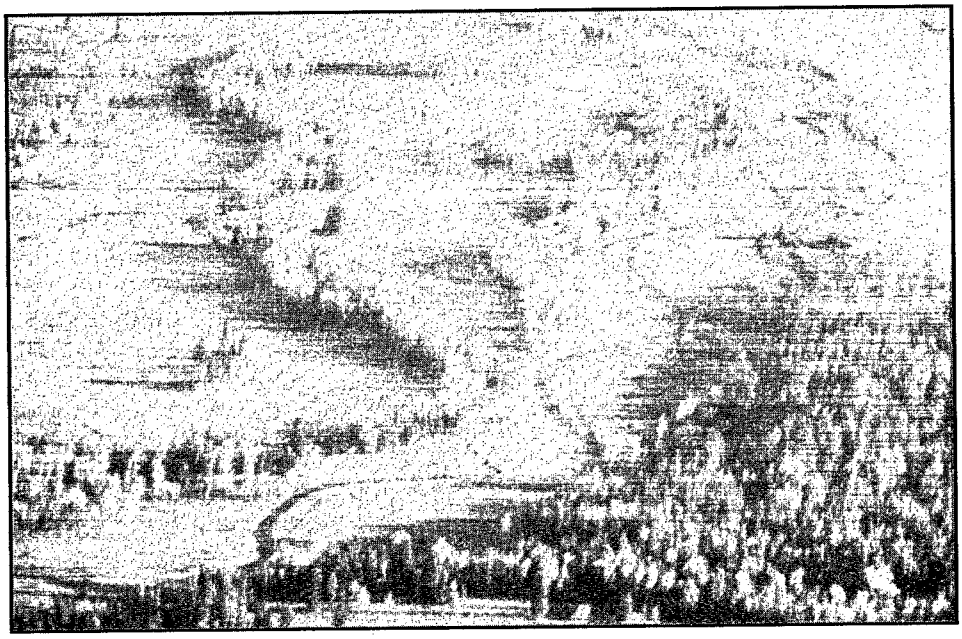
To demonstrate these application principles, a couple of brief examples of large-scale stream restoration projects are summarized.

Rio Blanco—Colorado

A reach of this river was straightened and leveed in the late 1960s. The traditional attempt at river control resulted in the development of a braided (D4) channel; in 1987, a 3.8-kilometer reach was converted to a meandering (C4) stream type. This project is summarized by the National Research Council (1992) and is shown at right.



Aerial view of the braided reach (D4), Rio Blanco, 1986, looking upstream.



Aerial view of Rio Blanco following restoration, showing meandering stream type (C4), 1992, looking upstream.

East Fork of the San Juan River—Colorado

The East Fork naturally converted to a braided channel as extensive willow eradication in the 1930s resulted in accelerated bank erosion and channel widening. The 8 kilometers of existing braided channel, with an average width of 350 meters, was responsible for contributing over 49 percent of the total annual sediment load of the 140-square-kilometer watershed due to accelerated bed and bank erosion. A restoration demonstration study was initiated as part of a section 404 permit through the COE. In 1986, a 1.6-kilometer reach of river was converted from a braided (D4) stream type to a meandering (C4) stream type. The meander geometry relationships and channel dimensions for a stable C4 stream type were emulated on paper, then implemented by constructing a new channel and floodplain. Monitoring has demonstrated that the pattern, profile, and dimensions of the new stream type have been stable. The competence of the river to transport sediment has been improved along with a greatly improved brown trout fishery and visual enhancement. A vegetated floodplain now exists

over previous gravel bars. Streambank stability was afforded by the implementation of a bank revetment and fish habitat design using a combination of willow transplants and cuttings, root wads, logs, and boulders. Fish habitat has been improved by increased depths for the same discharge, improved overhead and in-stream cover.

There are many additional restoration projects designed by the author that utilize natural stability concepts including, but not limited to: Wolf Creek, Bull Creek, and the Eel River in California; Quail Creek in Maryland; Lamoille and Maggie Creeks in Nevada; other rivers in Colorado, Idaho, Montana and North Carolina. Unfortunately, space limitations preclude their presentation here.

Summary

Results from monitoring these restoration projects, which have utilized natural stability principles, show the potential of alternative strategies to traditional large-scale river channelization. Rivers can be improved in their stability, visual values, water quality, riparian function, and terrestrial and aquatic habitats. Fish habitat improvement from this approach is greatly improved and becomes a central objective in much of this work.

Continued monitoring with similar projects will help all of us learn and improve our ability to "put something of value back" into our rivers. In this manner, we can demonstrate the ability to regain the stability, integrity, and natural functioning of our inherited fluvial systems for those who follow.

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Streambank Stabilization Techniques: Nonpoint Source Pollution Demonstration Project On Lower Boulder Creek, Colorado

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Watershed Description

Boulder Creek drains approximately 1,140 square kilometers (440 square miles) of the eastern side of the Colorado Rocky Mountain Front Range. The Boulder Creek basin is bordered on the west by the Continental Divide where headwater tributaries begin high in the Indian Peaks Wilderness Area. Middle Boulder Creek and North Boulder Creek join in Boulder Canyon at Boulder Falls (19.3 km (12 miles) upstream from the Boulder City limits), where the mainstem forms a medium-sized, fifth-order, cold-water stream ecosystem. Upon emerging from the mouth of Boulder Canyon, the stream flows through the urbanized center of the City of Boulder (population 95,000) and begins a transition from a cold-water (mean annual temperature of less than 20 °C) to a warm water system (mean annual temperature of greater than 20 °C). The transition between cold and warm is completed at the city's 75th Street Wastewater Treatment Plant WWTP approximately 13.4 km (8.3 miles) from the canyon mouth. The Creek continues as a warm-water stream as it becomes confluent with Coal Creek and St. Vrain Creek 13.7 km (8.5 miles) and 24.9 km (15.5 miles) downstream of the WWTP, respectively, before joining with the South Platte River.

The Boulder Creek watershed for purposes of this project was divided into upper Boulder Creek Basin (mountains) and lower Boulder Creek Basin (plains) (Figure 1). The mouth of Boulder Canyon serves as a natural boundary between the two basins.

The upper basin was defined as extending from the headwater tributaries at the Continental Divide to the canyon mouth, a distance of 38.6 km (24 miles). It includes 30,760 hectares (ha) (76,000 acres) of the Indian Peaks Wilderness Area, 2,630 ha (6,500 acres) of the City watershed that functions as the municipal water supply, and 46,360 ha (114,560 acres) of Arapahoe/Roosevelt National Forest. Total creek mainstem length from the divide to the confluence with Coal Creek and St. Vrain Creek approximates 65.6 km (40.8 miles) and 76.9 km (47.8 miles), respectively.

The lower basin extends from the mouth of the canyon to the St. Vrain Creek confluence. The 13.4-km (8.3-mile) reach between the canyon mouth and the WWTP includes properties under easement to the City of Boulder and is part of the city Open Space Greenbelt program. Along the 13.7-km

(8.5-mile) reach between the WWTP and Coal Creek confluence, land uses range from City-owned greenbelt and properties under easement to the City to privately owned agricultural operations. The remaining 11.3 km (7.0 miles) extends between Coal and St. Vrain Creeks and is dominated by irrigated agriculture, grazing, and gravel mining in Weld County.

Project History

In January 1985, City of Boulder public works officials were faced with renewing their National Pollution Discharge Elimination System permit, adopting more stringent un-ionized ammonia and other water quality standards, and upgrading the 17-year-old, 16-million gallons a day WWTP that was operating at greater than 80 percent capacity (Windell et al., 1991).

Point Source Pollution

Sources

Until data were analyzed from an ongoing water quality monitoring program by the City Water Quality Laboratory, it was not known that excursions of un-ionized ammonia were occurring in Boulder Creek. Excursions occurred on a daily basis between 10:00 A.M. and 6:00 P.M., causing transient exceedances of the state standard (0.06 mg/l) during the early spring months of March and April and the late summer and fall months of August,

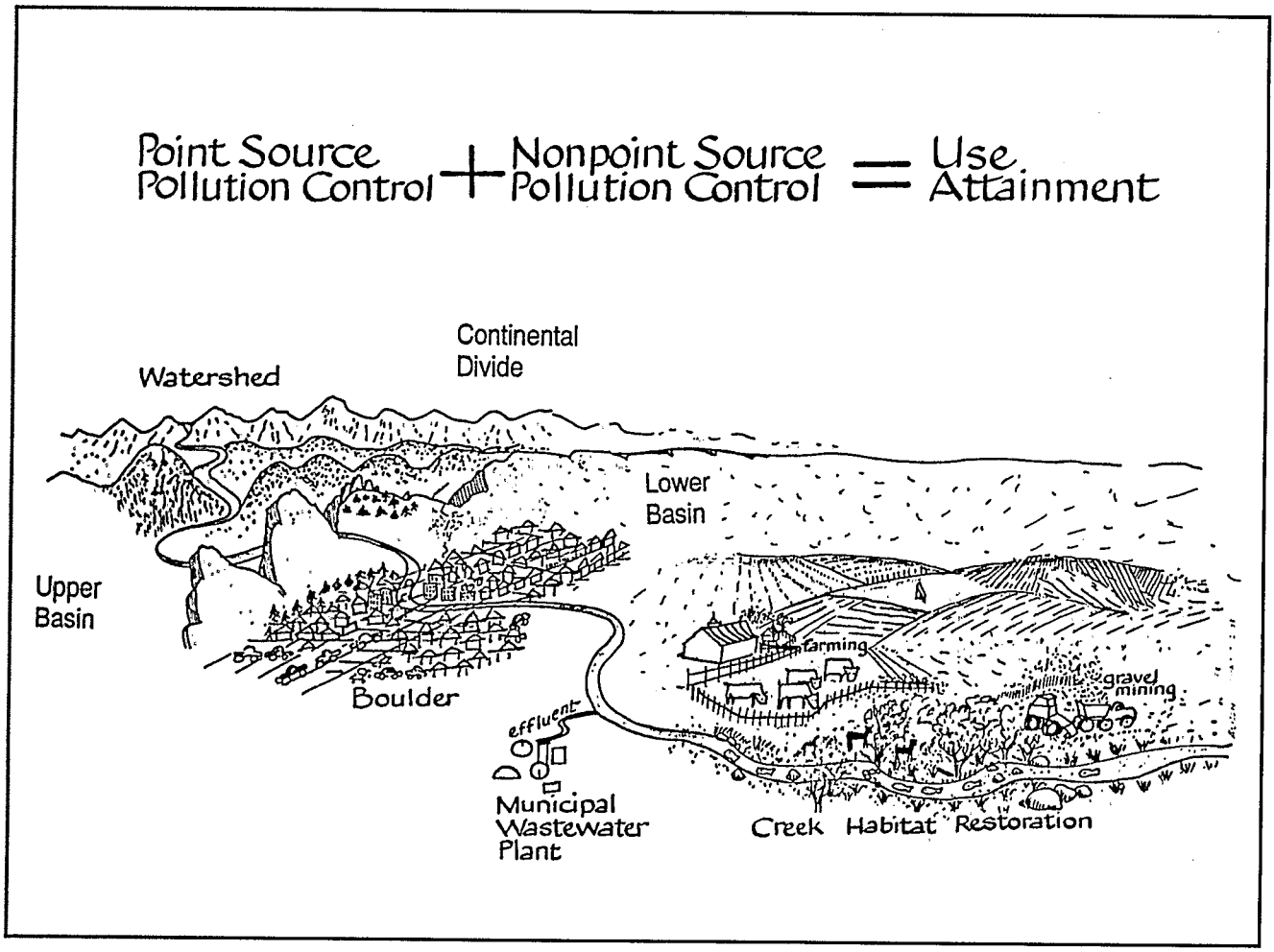

Figure 1. The Boulder Creek Watershed was divided into an upper basin (mountain) and lower basin (plains) where 12 BMPs have been implemented.

September, and October. Although these excursions were not technically a violation of the state standard, they were significant and presented a cause for concern by city and state officials. Data analysis also revealed a significant downstream rise in pH from 7.0 at the WWTP outfall to as high as 10.0 at a point 13.7 km (8.5 miles) downstream, suggesting possible nonpoint sources of pollution.

Solutions

City officials authorized a facilities and sludge management master planning study that presented analyses and recommendations for water quality improvement through the year 2010. Major recommendations included (1) WWTP expansion and upgrading to meet all water quality standards, (2) ammonia removal by addition of a nitrification tower to moderate the reported un-ionized ammonia excursions, and (3) development of a long-range plan to meet the aquatic life use classification. Funding for the first two recommendations was secured, and a $23 million plant expansion and upgrade was completed in 1989.

Nonpoint Source Pollution

Although the WWTP was able to meet instream water quality standards by 1989, point source pollution control was, as an isolated measure, deemed inadequate to fully restore the aquatic life use. It became clear that both point source and nonpoint source (NPS) controls would be required to achieve instream water quality goals. The cost to produce a high-quality effluent that meets and exceeds all water quality standards, but must be released into a stream that is degraded and polluted by nonpoint sources, could not be defended or justified.

Sources

Several early reports documented NPS pollution inputs resulting from poor land use practices prior to 1985 (DRCOG, 1983, 1979, 1977; USEPA, 1982). It was reported that nonpoint sources would contribute a significant amount of pollutants to the drainage basin by the year 2000. For example, regional planning studies predicted that nonpoint sources could account for up to 60 percent of the biological oxygen demand, 83 percent of the total dissolved solids, and 82 percent of the nitrate to the total loading in the Boulder Creek basin. Nonpoint sources were also predicted to contribute 30 percent of the phosphates and 17 percent of the ammonia in the basin.

The un-ionized ammonia excursions, extreme pH values, high water temperatures, and other factors prompted city and state officials to conduct a 1-day field trip between the WWTP outfall and St. Vrain Creek 24.9 km (15.5 miles) downstream. A variety of NPS problems were confirmed. This caused significant doubt about the ability of the creek to meet its Warm Water Class I use designation and whether it could be achieved in 20 years.

Additional environmental investigations conducted by the City between 1985 and 1988 demonstrated that the creek was highly dysfunctional and being severely impacted by nonpoint sources. A use attainability study was conducted to document (1) physical habitat characteristics, (2) discharge, (3) irrigation diversion dams and return flow ditches, (4) riparian and aquatic vegetation, and (5) macroinvertebrate and fish community structure and function (Windell and Rink, 1987). An 18-month, biweekly, 24-hour sampling study was conducted to document water quality at the Boulder Creek and Coal Creek confluence (Windell et al., 1987, 1988). Spring and fall 24-hour synoptic studies were conducted to document the extent of the seasonal un-ionized ammonia excursions (Windell et al., 1988). In addition, interest in the feasibility of using aquatic and riparian habitat restoration to reduce unionized ammonia excursions provided impetus for initiating the phased NPS demonstration projects (Windell and Rink, 1987).

Upper basin NPS problems include highway and road sanding; assorted mining operations; forest damage; and sediment production caused by the Black Tiger Gulch fire, forest roads, development, and the accumulation of small habitat modifications related to poor land use practices.

Lower basin NPS problems include highway, street, and road sanding operations; sediment drainage from ditches, gravel mining areas, return flow irrigation ditches, and storm sewers; historic channelization, grazing, and streambank erosion; and destruction of riparian habitat

by road building, gravel mining, firewood cutting, and grazing.

The purpose of this paper is to document the overall progress of the first three phases of the demonstration project and report preliminary monitoring data for techniques used to reduce sediment contributed by stabilizing eroded streambanks.

Solutions

The initial NPS demonstration project was completed in the spring of 1990, comprising 2.3 km (1.3 miles) of discontinuous restoration treatment (Table 1). A second phase, completed during spring 1991 added 1.8 km (1.1 miles). In the spring of 1992 an additional 0.8 km (0.5 mile) was added in a third phase. A fourth phase is currently under design for restoring an additional 2.7 km (1.7 miles), for a total of 7.4 km (4.6 miles) of physical, biological, and chemical habitat restoration (Figure 2).

A total of 12 different best management practices (BMPs) have been implemented during Phases I, II, and III. These can be grouped into three major categories: (1) riparian habitat, (2) water quality, and (3) aquatic habitat (Table 2). Five of the 12 BMPs were designed to stabilize highly erodible streambanks by implementation of biotechnical slope protection treatments.

Sediment Control and Reduction

The field survey identified 72 areas of eroding streambanks. Lengths of individual sites ranged from 6 to 245 m (20 to 800 ft) for a total length of 3,423 m (11,230 ft) or 3.4 km (2.1 miles). The height of the eroded banks varied considerably and ranged from 0.3 m (1 ft) to 8.0 m (26 ft). Surface area per eroded site ranged from 2.3 (25 square feet) to 745 m (8,000 square feet). Consequently, the BMPs of choice included: excluding cattle from riparian habitat with wildlife-compatible fencing, and repairing erodible streambanks using five different BMPs to reduce the annual sediment input.

Log Revetment. Log revetment was applied at four locations totaling 217 m (712 ft) in length. The height of the eroded streambank dictated the number of 0.3-m (12-in) to 0.5-m (18-in) diameter logs that were stacked on top of each other at each location. Each log was placed parallel to an eroding streambank and cabled to buried deadman logs placed 1.5 m deep and 3.0 m back from the water edge. Crevices behind the logs were backfilled, planted with live willow stakes, and seeded.

Jetties. Eleven jetties of two types were constructed at five separate locations. Both types were constructed with a layer of rock forming a hollow base. Brush layering was placed on top of the base rock and covered with another layer of rock. The center of the jetty was filled with substrate and planted with live willow stakes.

One type of jetty was used to concentrate low flow in one channel by blocking braided side channels, thereby reducing the wetted streambed surface area. Reducing the wetted streambed surface area decreased the amount of photosynthesizing vegetation during the spring and fall low flow un-ionized ammonia excursion periods.

A second type of jetty was placed against highly eroding banks, extended into the current for 3.0 m and angled downstream. Water

Table 1. Summary data for lower Boulder Creek NPS Pollution Demonstration Projects. Phases I, II, and III completed. Phase IV(a) is in final design.

	Phases and Reach Number				
Characteristics	I 5(b)	II 4	III 5(a)	IV(a) 6(a)	IV(b) 6(b)
Project Length (m)	2,092	1798	838	2,682	2,590
Project Length (ft)	6,864	5,900	2,750	8,800	8,500
Upstream Elevation (m)	1,539	1,548	1,542	1,530	1,518
Upstream Elevation (ft)	5,050	5,080	5,059	5,018	4,979
Downstream Elevation (m)	1,532	1,543	1,539	1,518	1,510
Downstream Elevation (ft)	5,028	5,064	5,050	4,979	4,954
Elevation Decrease (m)	7	5	3	12	8
Elevation Decrease (ft)	24	16	9	39	25
Gradient (%)	0.3	0.3	0.3	0.4	0.3
Sinuosity	1.1	1.4	1.1	1.0	1.0
Percent Channelized	100	54	100	100	100

1. Length of Boulder Creek receiving partial NPS treatment during Phases I, II, III = 4.73 km (4,729 m).
2. Length of Boulder Creek between WWTP and Kenosha Road needing partial NPS treatment = 10,000 m (10.0 km).
3. Weiser property located upstream of Phase II not treated.
4. Hartnagle property located between Phases II and III not treated, but shows a 2-m decrease in elevation.

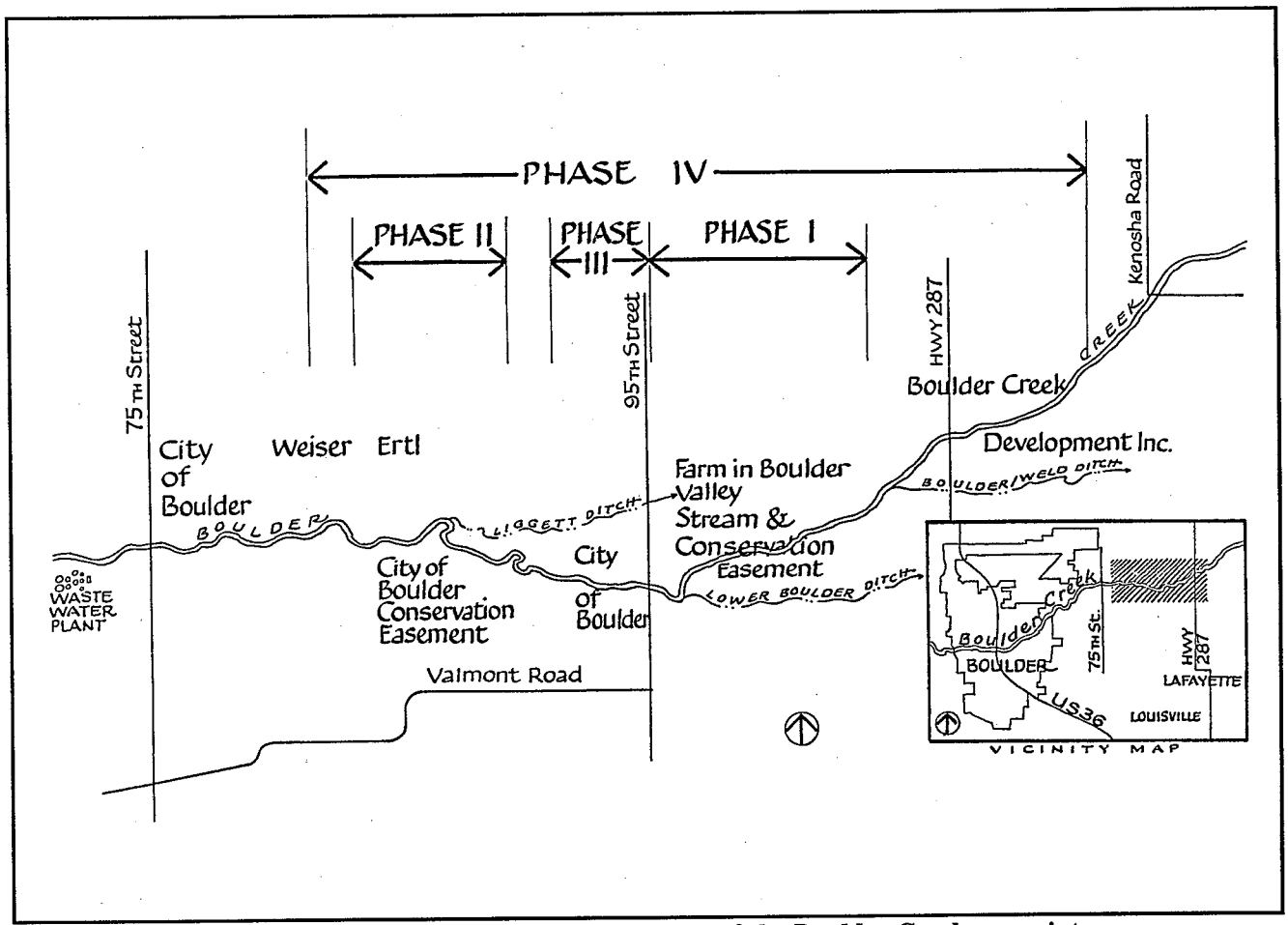

Figure 2. Land ownership and locations of the four phases of the Boulder Creek nonpoint source pollution demonstration project.

was deflected away from the bank, thereby decreasing the erosive forces that the bank is normally subject to during the spring runoff. Backeddies were created between the jetties and resulted in gradual sediment deposition that is expected to result in bank restoration.

Wattling. Wattling was installed at nine locations for a total length of 348 m (1,143 ft). The severely eroding banks were either cut, or cut and filled after placing boulders averaging 0.6 m in diameter at the toe of the slope. Erosion control fabric (COIR) was placed against the boulders prior to cutting the slope. Wattles were formed from sandbar willow cuttings, placed in a shallow trench, covered with fabric, and staked to prevent washout during the high spring runoff flows. The area upslope of the boulder toe and wattles was planted with cottonwood poles and reseeded.

Table 2. Groupings of the 12 implemented best management practices according to habitat type

Nonpoint Source	BMP
Riparian Habitat	
Overland Flow	- Fencing - Vegetation Planting/Seeding - Berm Removal
Streambank Erosion	- Log Revetment - Jetties - Brush Layering - Wattling - Boulder Toe/Brush Bundle
Aquatic Habitat	
Excessive Width & Shallow Depth/Aquatic Weeds	- Narrow Channel w/ Low Flow Pool/Point Bar/Tailout
Flat Water	- Rock Aeration Structure
Diversion Dams	- Fish Passage Structure
Water Quality Habitat	
Irrigation Ditch Return Flows	- Wetland Habitat Enhancement

Brush Layering. Brush layering was installed at nine locations for a total length of 408 m (1,338 ft). Boulders averaging 2 feet in diameter were placed parallel to the eroded bank at the toe of the slope. Sandbar willow cuttings (one per 3 cm) were placed over top and between the boulders, and erosion control fabric was placed on top of the willows. The bank was then cut to a 2:1 slope, with part of the cut material anchoring the fabric in place. The fabric was pulled back away from the boulder toe and staked. A second brush layer was put in place 0.3 to 0.5 m (12-18 in) above the first, fabric applied, and staked. The area immediately above the brush layer was planted with cottonwood poles and reseeded.

Boulder Toe/Brush Bundle. A boulder toe/brush bundle technique was restricted to eroded banks 0.8 m (2.5 ft) in height or less and installed at four locations for a total length of 126 m (415 ft). Boulders averaging 0.6 m (2 ft) in diameter were placed at the toe of the slope and parallel to the bank. Bundles of sandbar willow cuttings were placed on top and between (one cutting every 3 cm) the boulders before the space behind the boulders was carefully backfilled and seeded.

Summary

Initial post-treatment monitoring observations and preliminary analysis suggest considerable differences in the effectiveness of the five BMPs used to control streambank erosion. Additional monitoring will be required to determine the long-term effectiveness, constructability, durability, and cost benefits of the individual treatments.

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Establishment of Regional Reference Conditions for Stream Biological Assessment and Watershed Management

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Biological assessment to determine the status of aquatic resources is based on comparison of aquatic biota to reference conditions (Plafkin et al., 1989). Reference conditions are expectations on the status of biological communities in the absence of anthropogenic disturbances and pollution; they represent ideal biological integrity. The expectations must be based on the state of reference sites which, at best, are minimally impaired by human pollution and disturbance, but may be subject to anthropogenic influences. Establishment of reference conditions is thus dependent on the selection of appropriate reference sites and characterization of a reference database. This paper describes the process of definition and selection of reference sites for streams of the Central Appalachian Ridge and Valley ecoregion, for use in state and U.S. Environmental Protection Agency (EPA) regional monitoring programs and watershed management.

EPA Region III Environmental Services Division is developing a regional assessment program for the biological status of streams in the Central Appalachian Ridge and Valley ecoregion, known as the Regional Environmental Monitoring and Assessment Program (R-EMAP). A central component of this program is identification and characterization of stream reference conditions, which will be used as a basis of comparison for assessing biological integrity in state and regional monitoring programs. Reference characterization will also be the initial step in developing and implementing biological criteria.

Reference conditions are best established on an ecoregional (biogeographic) basis (Gallant et al., 1989), because both biogeographic patterns and environmental problems tend to be regional. An advantage of a regional framework is that states that share the same ecoregion can cooperate across boundaries to share reference sites and data, reducing their costs as well as improving the quality of their information. This project illustrates the kind of interstate cooperative effort that can produce reference sites and subecoregions independent of political boundaries. Where ecoregional biological criteria and use designations have been tested, they have proven to be a cost-effective and protective tool (Hughes, 1989).

Recognizing that absolutely pristine habitats do not exist (even the most remote streams are subject to atmospheric deposition), managers must decide on an acceptable level of disturbance to represent an achievable or existing reference condition. A critical element in establishing reference conditions is thus deciding how much impact or degradation is to be allowed for reference sites. Acceptable reference

conditions will differ among geographic regions and states because soil conditions, stream morphology, vegetation, and dominant land use differ between regions.

Classification: The Ecoregional Framework

Human beings identify objects and classify them into pigeonholes, which makes the bewildering complexity of nature more tractable. The purpose of classification is to group similar things together, i.e., to prevent comparison of apples and oranges. Meaningful classification is not arbitrary (an apple is not an orange). Classification invariably involves professional judgment to arrive at a workable system that separates clearly different ecosystems, yet does not consider each waterbody or watershed a special case. By classifying, we reduce the complexity of biological information.

Biologists have long noted that assemblages and communities can be classified according to distinct geographical patterns (e.g., Wallace, 1869; MacArthur, 1972). We observe areas of the country within which there is consistency and similarity in the types of ecosystems and their attributes when compared to that of other areas. The recognition of spatial patterns occurs at various scales; broad scale patterns are noticed at national levels; local spatial patterns are seen at finer scales.

The ecoregion sets landscape-level features such as climate, topography, regional geology and soils, biogeography, and broad land use patterns (Gallant et al., 1989; Hughes et al., 1990; Omernik and Gallant, 1990). It is based on geology, soils, geomorphology, dominant land uses, and natural vegetation (Omernik, 1987). Seventy-six ecoregions were originally identified in the conterminous United States; recent refinements have yielded a finer resolution of certain ecoregions, including the Ridge and Valley ecoregion under consideration here (Omernik et al., 1992).

Ecoregion and subregion are usually the only classification necessary to characterize natural communities. On occasion, further classification may be required, and a hierarchical classification scheme is most useful to identify distinct classes of streams. Classification should be parsimonious to avoid proliferation of classes that do not contribute to assessment or understanding, and to avoid classifications reflecting human disturbances to a stream.

The Central Appalachian Ridge and Valley Ecoregion

Subregions

The Ridge and Valley region of the Appalachians consists of sharply folded sedimentary strata that have been eroded, resulting in a washboard-like relief of resistant ridges alternating with valleys of less-resistant rocks. The region has been divided into four subregions corresponding to ridges and valleys of different parent material (Omernik et al., 1992):

- *Limestone valleys.* Are dominated by calcareous bedrock and calcareous soils, with numerous springs. The subregion has fertile, well-buffered soils suitable for agriculture, and has been settled and farmed since Colonial times. Land use is predominantly agricultural (row crops and dairy), and small to medium sized cities are scattered throughout (e.g., Harrisburg, PA; Hagerstown, MD; Winchester, VA). Streams are low to moderate gradient with high alkalinity due to the calcareous bedrock and soils, and with high nutrient concentrations due to intensive agriculture.
- *Shale valleys.* Are dominated by non-calcareous bedrock, primarily shale. Land use is also predominantly agricultural, but of lower intensity than in the limestone valleys (e.g., pasture for nondairy livestock, hay). Streams are low to moderate gradient with low alkalinity. Streams in shale valleys may go dry in late summer or fall of dry years.
- *Sandstone ridges.* Are dominated by highly resistant sandstones. Land use is predominantly forest, streams are steep to moderate, and water has low alkalinity.
- *Shale ridges.* Are dominated by shale bedrock. Land use is predominantly forest, stream gradients are steep to moderate, and water has low alkalinity. Streams on shale ridges frequently dry up in fall.

Each subregion imparts characteristic topography, hydrology, and water chemistry

to streams, and hence influences biota. The subregions are not continuous and interdigitate throughout the Ridge and Valley, yet each occurs in all four states.

Site Selection

Following delineation of subregions (Omernik et al., 1992), meetings were held with state water quality monitoring biologists to develop selection criteria in light of different expectations in each of the subregions, and to identify candidate reference streams from topographic maps. Site selection criteria were identified based on past experience with potential stream problems in the region. State biologists had been supplied with maps of subregions, and were asked to identify candidate sites in each subregion. Subregion-specific reference site criteria were considered, with the aim of developing criteria that would allow one or two reference sites per subregion in each state.

It was recognized at the outset that unimpacted sites would be readily available on the ridges, where land use is predominantly forest, and where protected lands (e.g., national forests, recreation areas) are common. In contrast, nearly all streams in the valleys, and especially in the limestone valleys, are impacted by agriculture, habitat modification, and other nonpoint sources. Therefore, two approaches were taken to defining reference sites, reflecting the different land uses in the subregions. Reference sites for the ridges were strictly defined to be unimpacted except by atmospheric sources: no discharges, nearly complete forest cover in the drainage, and no recent construction or clearcutting in the drainage (Table 1). The approach taken for the valleys was to select the best sites available, keeping the definition flexible enough to allow a sufficient number of reference sites to be selected.

Several criteria are universal to all four subregions, several others differ

Table 1. Ridge and Valley reference stream criteria

Parameter	Limestone Valley	Shale Valley	Shale Ridge	Sandstone Ridge
Watershed				
Drainage	Entirely within subregion No upstream reservoirs	Same	Same	Same
Land use	No major recent disturbance Best available Least agriculture from among possible sites	No major recent disturbance Minimal agriculture	>80% forest, no agriculture (MD, WV, VA) Minimal agriculture (PA) No major recent disturbance (including logging)	>80% forest, no agriculture No major recent disturbance (including logging)
Stream Habitat				
General	Minimal cattle impact No watercress farms (WV) No fish hatchery	No cattle in stream	No cattle in watershed (PA)	No disturbances
Channel Morphology	Characteristic of subregion	Same	Same	Same
Riparian vegetation	Best possible	> 5m for 0.8km (PA) Best possible (WV)	> 5m for 1.6km (PA) > 30m (WV, VA)	Most of stream length, > 30m (WV,VA)
Instream substrate	Least siltation or embeddedness	Least siltation or embeddedness	No significant siltation or embeddedness	No significant siltation or embeddedness
Water Quality				
General	No point sources No recent spills	Same	Same	Same
pH	n.a.	>6	>6	>6

among the subregions (Table 1). There are no undisturbed catchments in the entire Limestone Valley watershed subregion, as reflected in the criteria allowing minimal agriculture in a reference stream watershed. Dairy operations are common, and cattle are frequently seen in streams. However, it is possible to find streams with smaller overall impact of livestock (Table 1). Agriculture is less intensive in the Shale Valley subregion, and it was possible to define criteria with lesser impact of agriculture for reference streams in the shale valleys. The two ridge types (shale and sandstone) have been historically used for extractive and recreational industries (quarries, logging, hunting), and forest is widespread in these subregions. The reference site criteria for the ridge subregions require that most of a catchment be stable forest with no recent disturbance (Table 2). Following selection, candidate sites were visited to determine their suitability, with attention paid to habitat conditions, including agriculture, dwellings, roads, riparian vegetation, watershed vegetation, and instream habitat.

Thirty-one final reference sites were selected by this process, with eight each in the Limestone Valley, Shale Valley, and Sandstone Ridge subregions, and seven in the Shale Ridge subregion. Reflecting the distribution of the Ridge and Valley ecoregion, there are 13 sites in Virginia, 11 in Pennsylvania, 4 in West Virginia, and 3 in Maryland.

Table 2. Preliminary stream classification and subregions of Ridge and Valley

Area	Stream Water Type	Dominant Fishery	Corresponding Subregion
	low conductivity	cold water	Shale Ridge, Sandstone Ridge
Highland	high conductivity (due to calcareous cement in rock formations or minor limestone strata)	cold water	Sandstone Ridge
Valley	limestone spring (high conductivity)	cold water	Limestone Valley
	limestone influenced (high conductivity)	cold or warm water	Limestone Valley
	low conductivity	cold or warm water	Shale Valley

The different approaches to the subregions will be carried through characterization. Ridges can be characterized using measures of central tendency (mean or median), because we are confident that the reference sites represent unimpaired conditions. Characterization and scoring for the two valley subregions (limestone and shale valleys) will be done using upper percentiles (90 percentile) of the reference station data distribution, such that the data range below the 90th percentile is trisected for assigning scores, as is done for Index of Biotic Integrity and Rapid Bioassessment Protocols scoring (Karr et al., 1986; Plafkin et al., 1989).

Secondary Classification

Prior to identification of subregions in the Ridge and Valley ecoregion, regional biologists had developed a preliminary classification of streams in the ecoregion. The classification and its relationship to the subregions is shown in Table 2. The *a priori* classification was developed by stream biologists independently of the subregionalization, and illustrates the close parallels between observations of stream biology and subregions developed by geographers from mapped information.

The final stream classification of the Ridge and Valley must await collection of biological data from reference streams. Biological data will be used to verify the ecoregions and the secondary classification.

Regional Reference Conditions and Watershed Management

Management of water resources is moving towards watershed management because of the realization that waterbodies reflect the state of their watersheds, and effective management can only take place by managing watersheds. The watershed is thus the most appropriate "management unit."

At the same time, we see that most natural characteristics of stream habitats—slope, vegetation, water chemistry, hydrology—are common to an ecoregion, and these characteristics determine to a large degree the natural biota of the stream. The ecoregion thus is the template that sets broad

habitat and biological characteristics, and forms the basis for defining reference conditions. These reference conditions are the criteria and goals for management and restoration.

Ecoregion and watershed do not always coincide. Although any ecoregion contains many watersheds, a large number of watersheds cross regional boundaries. This is especially true for the Ridge and Valley, where even small watersheds may be partially in different subregions. Third order streams and larger almost invariably receive waters from different subregions.

Watershed managers need to be cognizant of ecoregions, so that expectations and goals can be set accordingly. With the development of regionwide reference site databases, realistic and scientifically-defensible reference conditions can be established to form a basis for water quality management goals.

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Tailoring Requirements to Reality: The Santa Ana River Use Attainability Analysis

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Background

The Santa Ana River (SAR) begins in the foothills of the San Bernardino Mountains and, except for its uppermost reach, runs through urbanized areas to the Pacific Ocean approximately 50 river miles downstream. The SAR is naturally ephemeral until rising ground water creates permanent flow in the lower two-thirds of its length. In recent years, increasing discharges from municipal water reclamation plants (Publicity Owned Treatment Works (POTWs)) have increased the volume of permanent flow, and have extended hydraulic continuity to its upper reaches.

The SAR's designated uses include warm-water aquatic life, recreation class 1, agricultural irrigation, ground-water recharge, industrial process water, and hydroelectric power. Though not a designated use, the river is also used to provide flood control; it is lined, channelized, and routinely stripped of vegetation, and is broached by two dams. Additionally, the SAR is affected by rising ground water that has been contaminated with nutrients and a high total dissolved solids by historical agricultural activities.

The SAR is an important water resource to three counties. It provides a point of discharge and reuse for reclaimed water, it provides recharge of ground-water supplies for drinking water, and it provides a source of varied recreation for numerous communities. Water reclamation utilities, water supply utilities, and regulatory agencies have intense, and often competing, interests in the river. Areawide basin planning is an ongoing and important task that all of these parties participate in actively. The results of such planning activities have long-range impacts on the overall management of the river, and establish water quality "objectives" (criteria) and discharge permit requirements that carry substantial costs and long-term implications for river use priorities.

Ammonia water quality objectives to protect the aquatic life use, in conjunction with the nitrate requirements, were resulting in nitrification and denitrification treatment processes at all discharging POTWs. California's Title 22 regulations with respect to protecting human health from recreational exposure to viruses mandated a specific tertiary level of treatment or a "demonstrated equivalent." The SAR was also added to the Clean Water Act Section 304(l) list because of six metals (cadmium, copper, lead, chromium, mercury, and silver) discharged by six POTWs. The

California Inland Surface Waters Plan implemented statewide standards (essentially EPA "Gold Book") as well as rigorous acute and chronic toxicity requirements. The cumulative impact was $2 billion of capital improvements for the six POTWs in communities already under economic stress. One of the few things that was clear was this—what the river could and should support was unclear. The potential for costly management decisions with no concomitant benefit was a real possibility.

Purpose of the Use Attainability Analysis

As a result of this situation, and out of a need to address state and federal regulatory requirements, as well as properly address local planning needs, the Santa Ana Watershed Planning Authority (SAWPA) undertook a comprehensive use attainability analysis of the entire river. The use attainability analysis (UAA) was designed to address the ammonia issue, the heavy metals issue, and to provide an overall characterization of the SAR to assist in making basinwide management decisions. The basic goals of the UAA were to determine the uses of the SAR and what standards were needed to protect them, to identify potential uses of the SAR that could reasonably be attained, and to ascertain what factors enhance or inhibit the ability to achieve designated uses.

Scope of the Use Attainability Analysis

To achieve these goals, the Santa Ana River UAA was extensive. A total of 39 sampling stations, plus the 6 POTW discharges, were carefully selected for their representativeness and to provide a complete profile of the river. Final site location determinations were made by the research team in conjunction with state regulatory officials. Of these 39 sites, 21 were full study sites and 18 were reconnaissance sites.

Additionally, the Santa Margarita River, including its tributaries, was used as a "reference reach," with a total of 11 additional full study and reconnaissance sites. The Santa Margarita River system was outside a populated area, and had no point source discharges to it. The river was in the same basic geographic area and experienced the same general climatological influences.

Full study sites received the full suite of samplings and analyses listed below. Reconnaissance sites received some combination of the listed parameter investigations.

In order to assess any impacts seasonal variation might have on the character of the SAR, samplings were collected quarterly for one year, beginning in March 1991 and ending in November 1991. In all, over 10,000 individual determinations were made and analyzed as part of the UAA.

The parameters for which sampling and analysis were conducted, and for which scientific determinations were made were:

Water Chemistry
- 10 heavy metals (As, Cd, Co, Cu, Cr, Pb, Se, Hg, Ag, Zn)
- Nutrients (NH_3, NO_2, NO_3, TKN, and Total P)
- Organics (EPA Methods 602, 608, 624, 625)
- General constituents (TSS, TDS, alkalinity, minerals, TOC, COD, HCO_3, conductivity, and Fe)

Physical Parameters
- Instantaneous flow, river depth, flow velocity, pH, air and water temperature)

Microbiological Analysis
- Indicator bacteria (total and fecal coliform, enterococci)
- Virus (enterovirus, rotovirus, Hepatitus A)
- Protozoa (*Giardia* sp. and *Cryptosporidium* sp.)

Habitat Assessment

Biomonitoring
- Acute (*Pimephales promelas* and *Ceriodaphnia dubia*)
- Chronic (*Pimephales promelas* and *Ceriodaphnia dubia*)

Biological
- Fish collections
- Invertebrate enumeration
- Algae survey

Fish Flesh Analysis
- For bioaccumulation of metals and organics

Hydrologic Characterization

Socioeconomic Impact Analysis

Use Attainability Analysis Technical Approach

In order to ensure the comprehensiveness of the UAA, to maximize the integra-

tion of data collected, and to ensure the scientific validity and usefulness of the data collected, a rigorous technical approach was developed, reviewed by all involved parties, and refined. Components of this technical approach are summarized below.

Development of Research Hypotheses

The Technical Oversight Committee established by SAWPA to oversee the technical design and conduct of the UAA determined to use hypothesis testing as one means to evaluate the results of the UAA. Through a consensus approach involving all interested parties, a series of research hypotheses was developed that would guide assessments of aquatic life issues, drinking water and human health issues, nonpoint source issues, and the basis for placing the SAR on the federal 304(l) list.

A suite of metrics was also established by which to make qualitative and quantitative measurements. These metrics included, for example, biodiversity indices, dissimilarity and similarity coefficients for invertebrates, richness and composition, trophic composition, and abundance and condition factors for fish.

Water Quality Monitoring Methodologies

Water quality collections were conducted in the same time frame as biological collections and habitat assessments in order to examine correlation. The UAA data were used to validate historical data, thus expanding the volume of data that could be analyzed and the time frame over which such data evaluation results could be applied. The water quality assessments conducted during the UAA were done during the fifth year of an extended drought, a time when water quality stresses were at their maximum.

The analytical methods used were EPA-approved methods designed to achieve the lowest detection limits. The heavy metals, with the exception of mercury, were analyzed by Inductively-Coupled Plasma/ Mass Spectroscopy. Mercury was analyzed using Cold Vapor Atomic Absorption.

A *Field Sampling Procedures* manual was specially written for use in collecting and handling samples. This manual provided precise instructions on holding times, containers, and preservation techniques for all parameters measured. It provided explicit labeling and shipping instructions, and provided chain of custody directions. Quality assurance and control provisions included travel blanks, field blanks, field duplicates, control standards, and sample splits. Duplicate analytical laboratories were used to cross-verify results. Specific field testing procedures were developed, in detail, and were included in the manual as were sample collection procedures.

All field personnel were trained by the Principal Investigator, and specific field monitoring documentation materials and procedures were developed, implemented, and adhered to assiduously. Special equipment was developed, and procedures for its proper use were implemented. Every sample was collected, labeled, and shipped by the Principal Investigator or under his direct supervision. Every analytical laboratory involved in the UAA was visited and audited by the Principal Investigator prior to and during the conduct of the UAA.

Microbiological Sampling Methodologies

A separate section of the *Field Sampling Procedures* manual was developed for microbiological sampling, including indicator bacteria and virus and pathogen screening. Viruses were assayed directly. Two methods were used: observation of cytopathogenic effects of tissue cultures and gene probes. The virus and protozoan assays were conducted by the University of Arizona by the methods developed by Gerba and Naranjo.

Biological Survey

The biological survey was a seasonal sampling of the biological populations and assessment of communities. All sampling was conducted in the same time frame as the water quality sampling. Habitat assessments were conducted during each sampling to allow correlation between biological sampling results, water quality sampling results, and habitat factors.

Habitat Assessment Methodologies

Habitat assessment was primarily conducted using the EPA's Rapid Bioassessment Protocols (RBP). This method uses empirical information collected at several

representative sites to assess biological integrity and to identify possible changes in community structure and abundance resulting from point and nonpoint pollutant sources. The RBP were used to score the habitat on primary, secondary, and tertiary parameters.

- *Primary Parameters:* (Substrate and cover) scored bottom substrate, available cover, embeddedness, and flow volume and velocity.
- *Secondary Parameters:* (Channel morphology) scored channel alteration, bottom scouring and deposition, pool/riffle ratio, and run/bend ratio.
- *Tertiary Parameters:* (Riparian and bank structure) scored bank stability, bank vegetation, and sidestream cover.

Riparian Vegetation Survey

A comprehensive vegetation survey was also conducted. Four measurements were made: vegetation height, crown diameter, distance to the water's edge, and vegetation density. Representative vegetation stands were used that would characterize each river bank. Aerial photography was employed to divide the river into segments of similar vegetation characteristics.

Stream Water Temperature Modelling

Because many of the statewide water quality criteria were calculated based on cold water species, and because the natural temperature of the SAR can exceed 30 degrees Celsius in some reaches, precluding many species of aquatic life, it was necessary to determine the river's temperature profile. It was also necessary to determine what physical factors controlled the water temperature. To accomplish this, the U.S. Fish and Wildlife Service's Instream Water Temperature Model—Stream Network Temperature was used. Inputs to the model were made from historic records, topographic maps, and field surveys. The model was calibrated and verified against actual stream measurements.

Fish Collections

The fish population was sampled at all SAR and reference reach sites using Coffelt backpack electrofishing gear. Sampling was conducted on measured stream sections, typically 150-foot to 450-foot sections.

All fish sampled were identified to species, counted, measured for length, and weighed. These samplings provided species lists and relative abundance estimates. Population structure was used to determine the source of the fish present at each site, i.e., naturally reproducing or recruited from off-channel sources.

Selected fish and crayfish collected during the samplings were kept and analyzed for residues of heavy metals and organic compounds using whole fish tissue samples (150-200 g). The ten heavy metals of interest in the water quality samplings were analyzed using EPA approved methods. EPA Methods 608 (pesticides), 624 (volatile organics), and 625 (base, acid, and neutral organics) were also conducted on the fish tissue samples.

Benthic Invertebrate Enumeration

The benthic invertebrate populations were sampled quantitatively at each full site by taking three replicates (each a composite of two samples) from the riffle habitats with a modified Hess sampler. Additionally, quantitative samples were collected from all sites using a kick-net sampler.

Analysis conducted provided species lists and estimates of density (number/m^2) and biomass (g/m^2) for each site. The Shannon-Weaver Diversity Index was also calculated for each site to measure the effects of any stress upon the organisms. In addition, the benthic community was analyzed using the EPA Benthic RBP III methodology.

Algae Survey

Periphytic algae were quantitatively sampled by scraping a known area of rock surface. Each sample was a composite of three rock scrapings. The shifting sand substrate of the SAR complicated algae sampling.

Analyses of the algae sampling produced a species list, density estimates, biovolume, and calculation of the Shannon-Weaver Index.

Laboratory Toxicity Testing

Acute and 7-day chronic toxicity tests, using EPA protocols, were con-

ducted on samples conducted on all six POTW effluents and several SAR sites using *Ceriodaphnia dubia* and *Pimephales promelas* during the same time frame as the other samplings.

Statistical analyses included Probit analysis for LC_{50} determinations and Dunnett's procedure and the Bonferoni t-test for chronic test results. Since this procedure could not provide an estimate of toxicity between the specific dilutions, or allow for the calculation of confidence intervals, chronic tests were also analyzed with the Impairment Concentration Percentage (ICP) method.

Biological Data Analysis

Cluster analysis was used as a method to describe and compare the natural communities in the SAR and reference reach. Cluster analysis is a form of classification whereby a group of entities (e.g., habitats, species) is ordered into groups or sets, based on the relationships of similarity of certain attributes (e.g., ordering habitat measures of similarity, Euclidean Distance "dissimilarity coefficient" and the Jaccard Coefficient of Community "similarity coefficient," were used to order groups).

The first step of the process involved the sampling process. Collected data included species lists, measures of species abundance, and habitat scoring from all sites. Next, two measures of ecological similarity were computed between all pairs of sites to quantify similarity or dissimilarity. Sites were grouped according to their resemblance for each attribute. Clusters were formed by sites with common characteristics that set them apart from sites in other clusters.

Socioeconomic Impact Analysis Methodology

A model was developed that analyzed first-order impacts such as the impacts upon utility rates, employment, earnings, and tax revenues. The model was based upon proven approaches, and generally followed EPA guidance on the determination of widespread and substantial social and economic impact as included in the Agency's "Draft Water Quality Standards Handbook." The model and its basic assumptions were reviewed and verified by economic experts from the federal government, a state demographer, and an academician and consulting economist to the Natural Resources Defense Council.

Second-order impacts such as the health impact of employment changes upon the local community, impacts upon housing affordability, impacts upon fixed and low income households, and the impacts upon bond ratings of the local governmental jurisdictions were also analyzed. The health effects impact analysis was conducted as a separate study performed by a researcher from the University of Missouri-Kansas City.

Use Attainability Analysis Management Approach

In addition to and concurrent with the technical approach to the SAR UAA, a comprehensive, integrated, and rigorous management approach was developed. This management component had two primary purposes: to ensure maximum credibility of the technical and scientific component, and to maximize the effectiveness of the UAA as an instrument of policy direction for regulatory and issues management.

Project Direction and Quality Control

Project direction was established, refined, and controlled by the UAA Task Force. The Task Force was composed of the members of SAWPA, including the discharging POTWs and water supply utilities, State Regional Water Quality Control Board representatives, and the project consultants and Principal Investigators. Also included on the Task Force were three Expert Consultants from academia—each nationally recognized for his work in water quality management and each familiar with the SAR.

Quality assurance was provided by the UAA Technical Advisory Committee, the technical arm of the UAA Task Force, and the close oversight and detailed review of the three Expert Consultants. This group reviewed and approved all methodologies. They reviewed and approved all raw data and interim reports after each sampling. The Technical Advisory Committee also devised and recommended additional project quality assurance and control techniques that were implemented by the project consultants.

Regulatory and Issue Management

While the SAR UAA was a scientific research endeavor, it was conducted because of and in accordance with complex state and federal regulations. Therefore, its focus, conduct, and management approach had to be fully integrated with the regulations and public policy issues involved. This effort included:

- A sophisticated documentation system that entered *all* meetings, correspondence, decisions, conflicts and resolutions, and methodologies development into the formal record. Prompt written responses to *all* issues were made in writing and entered into the record.
- An aggressive communication element that involved continuous coordination and communication, verbal and written, with all parties.
- Continuous parallel legal analysis and guidance to the project team that was integrated into the project approach.
- Frequent presentations on numerous technical and policy issues before the Regional Water Quality Control Board, State Board, and EPA. This process transmitted key information and built sound working relationships.
- A videotape summary of the UAA and its recommendations.

Use Attainability Analysis Findings

A summary of the findings of the Santa Ana River Use Attainability Analysis is presented below:

1. The aquatic habitat of the SAR is limited by natural physical factors that directly affect density and, to a lesser extent, the diversity of aquatic organisms. These limitations include high water temperatures, shifting sand substrate, inadequate cobble and bank vegetation, low base flows, intermittent flash flooding, and insufficient sheltering tributaries to support significant spawning.
2. Flood control activities and facilities adversely affect the aquatic habitat.
3. Discharges of reclaimed water from POTWs enhance many of the designated uses of the SAR system by increasing aquatic habitat, ground water recharge, and by supporting recreational uses.
4. Based on biological assessments of the integrity of aquatic communities, there was no evidence of impairment to the aquatic life use in Reaches 2 and 3 of the SAR and the Chino Basin tributaries. Existing water quality fully supported the aquatic life uses; additional treatment would provide no additional benefit.
5. Water quality in Reach 4 of the SAR did not fully support the potential beneficial aquatic life use. Biological, chemical, and toxicological evidence indicated impairment due to residual chlorine and unionized ammonia and nitrite.
6. Present levels of heavy metals (Cd, Cr, Cu, Pb, Hg, Ag, Se, and Zn) did not appear to impact the warm water aquatic life, recreational, or ground water recharge beneficial uses. Costly advanced treatment requirements for POTWs would not produce additional benefit. There was evidence of sporadic but significant nonpoint source contributions of some heavy metals.
7. Body contact REC-1 beneficial uses did not appear to be impaired by reclaimed water discharged by any POTW on the SAR. There was no discernible difference in water quality, as measured by the presence of indicator bacteria, pathogenic protozoa, or enteric viruses between POTWs that met California Title 22 tertiary filtration requirements and those that did not. There was evidence that nonpoint sources were contaminating the SAR system with high levels of bacteria, and relatively low levels of protozoa and viruses.
8. Nitrogen removal, Title 22 tertiary treatment requirements, and metals and TDS removal requirements, taken together would cause widespread and substantial social and economic impacts. After an initial construction-related increase, substantial unemployment would occur over the 20-year analysis period. Most unemployment impacts would affect lower income households. Health and social

consequences would result due to increased unemployment, including increased mortality of 4 to 18 cases per year over the 20-year analysis period. Illness such as heart disease, bronchitis, and mental health disorders would increase as would social problems such as crime, divorce, and abuse.

9. Utility rate increases, impacts on public debt, impacts on low income renters, and the impact on disposable income of people on a fixed income would be significant. The affected utilities' bond ratings would be negatively impacted.

Use Attainability Analysis Recommendations

The Santa Ana River Use Attainability Analysis also made a number of recommendations to better manage the SAR system, and to maximize the beneficial uses of the river. These recommendations are summarized by category.

Beneficial Use Modifications

- Subclassify aquatic life beneficial uses into:
  WARM-Class 1 (unrestricted): Represents a typical Southern California stream capable of supporting relatively large and diverse populations of aquatic organisms.
  WARM-Class 2 (habitat-limited): Represents a stream with severe habitat limitations that preclude full attainment of WARM-Class 1 regardless of water quality. A smaller, less diverse population of aquatic organism is expected due to natural factors.
  WARM-Class 3 (effluent-dependent): Represents a stream that can support larger and more diverse populations of aquatic organisms due to the discharge of reclaimed water from POTWs.
- Create new beneficial uses for flood control:
  FLOOD-Class 1: Represents a stream with minor channel alterations.
  FLOOD-Class 2: Represents a stream with significant channel alterations to support flood control purposes such as concrete lining that, by definition, cannot support WARM-Class 1.

Site Specific Objectives (SSO)

- Delete cold water aquatic species from the criterion and recalculate the water quality objectives using appropriate species.
- Adjust water quality objectives for heavy metals (Cd, Cu, Pb) to properly account for the effects of hardness, pH, and Total Organic Carbon. Adopt a translator mechanism to calculate permit limits based on the bioavailable fraction of the pollutant using the total/dissolved metals ratio. *(Specific detailed SSO calculations and rationales were provided in Volume III of the Final SAR UAA.)*
- For selenium and mercury, use 80 percent of the Food and Drug Administration Health Effects threshold, measured directly in fish flesh analysis, as action levels for source control instead of a chronic criterion below analytical detection levels.
- Adopt an interim un-ionized ammonia (UIA) objective of 0.4 mg/l. Use the Colorado Ammonia Model to calculate appropriate interim limits for each discharger, adjusting for temperature, pH, flow, and ambient ammonia concentrations. Conduct annual fish surveys for three years to determine improvements to the aquatic community. If such improvement is found due to water quality improvements, halve the UIA objective and repeat the process. (A specific decision matrix was developed and proposed in the UAA to guide this empirical process.)
- Employ direct measures of virus and pathogenic protozoa contamination, in addition to indicator bacteria, in lieu of mandated treatment processes.

Additional recommendations included continuous monitoring programs to isolate nonpoint sources of pollutants, the development of a regional environmental database to guide SAR Basin management decisions, and adjustments in river reach boundaries to represent their nature more accurately.

The SAR Use Attainability Analysis Is a Precursor to Watershed Management

The SAR UAA serves as a precursor model to a watershed management approach. The regional stakeholder group already existed. Regulatory agency representatives were involved throughout the project. The UAA was specifically designed to maximize the value and utility of the data collected. It provided a "big picture" view of the SAR that had not been clearly seen before, facilitating informed decision making.

The UAA started at the beginning of the water quality management process where every watershed plan should—assessing not only the character of the river, but also verifying that the goals and objectives were correctly set. This is a key issue. Most goals (designated uses and water quality criteria) have been established on the nation's waterbodies absent good data. This was done before the water quality-based regulatory program was in place. Now, these default goals and criteria have become sacrosanct. They are not. They must be scientifically reviewed and verified before elaborate management plans are developed and vast resources are committed to implement them. Not only can these resources be expended with no resultant environmental benefit, but also unintended consequences can result.

The SAR UAA has also made it clear that unless there is regional authority and flexibility to adjust goals and regulatory requirements to be compatible with local conditions and realities, the watershed management approach will founder due to lack of relevancy. This would be a tremendous loss of a vitally important and desperately needed problem solving and holistic water resource management tool.

Progress Report: Twenty Years of Watershed Planning in Southern California's Santa Ana River Basin

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Too many people and not enough water to go around—that's what led to the seemingly endless round of lawsuits and countersuits that characterized the 1960s in this watershed, which takes in parts of three separate counties. The last straw was a very expensive master court case that stretched over 6 years and pitted the Orange County users downstream against all those upstream in Riverside and San Bernardino counties. When the dust settled and the situation was finally resolved, the four water agencies that emerged as key players—Chino Basin Municipal Water District, Orange County Water District, San Bernardino Valley Municipal Water District, and Western Municipal Water District—began to consider alternative means of working out their problems, ultimately forming the Santa Ana Watershed Planning Agency (SAWPA).

SAWPA, which later changed its name to the *Santa Ana Watershed Project Authority*, provided both a forum for discussions and a vehicle for conducting studies and building projects of mutual interest. The geographic areas covered by the five agencies of SAWPA (Eastern Municipal Water District recently joined) include most of the developed areas in the watershed and over 95 percent of the population.

SAWPA began with a basin-wide study of water needs, wastewater treatment, and water quality. Then they initiated projects that benefited large parts of the watershed, including a brine export line that serves industry, ground water desalters, and pollution cleanup projects. SAWPA also began projects that serve smaller areas such as wastewater treatment facilities, water supply lines, and a lake level stabilization project at Lake Elsinore. In addition, SAWPA has a centralized regional data base, a geographic information system to interpret and display the data, and a number of locally-calibrated computer models.

SAWPA and the Regional Water Quality Control Board have worked together on a number of planning studies. Most recently, they produced:

- A regional waste load allocation for total dissolved solids and inorganic nitrogen.
- A use-attainability analysis and site-specific water quality objectives for the middle Santa Ana River.

Flows in the middle Santa Ana are made up primarily of high-quality treated wastewater, and there are severe environmental limitations on the aquatic habitat as well.

Today, SAWPA serves as a model for cooperative planning, problem solving, and project construction in other watersheds. They seem ready to deal with any kind of water quality or quantity problem that may arise.

*Former Chief of Planning; currently an Environmental Specialist.

"It's All Connected"

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"It's All Connected" is a campaign that is uniquely designed to educate community residents about simple, safe, and very specific ways they can make a personal contribution to the restoration and future protection of our nation's valuable water supplies. The campaign reflects an understanding that *community awareness results in resource protection.* It is through education that individuals find the tools they need to become active participants in the protection of their natural resources.

In this award-winning household pollution prevention campaign, the Lake Michigan Federation (LMF) has developed a comprehensive, community-wide education program. This pilot program includes home surveys, videos, slide shows, public service announcements, a poster depicting pollution sources around the home, and other printed materials (in English and Spanish), as well as curriculum, teacher in-service training, a traveling display, storm sewer stenciling, and programs for neighborhood groups and local retail outlets. The campaign is directed at eliminating pollution to watersheds from households and commercial sources. It has been designed as a model program for use in communities across the country.

Each component of the program is designed for replication to accommodate the different needs of communities. The videos and public service announcements can be easily edited to include local community contacts and information. The printed materials were designed so communities can simply insert their own local contacts and replicate the materials at a minimal cost. For a very small fee, masters can be purchased by any community. This way, communities can implement a proven and productive pollution prevention campaign without the high costs of development and production. The major costs incurred by communities will be for replication and dissemination.

Although the program is only being formally introduced across the country this month, hundreds of requests have poured in for materials and information. In addition, the campaign has enjoyed much attention from the media. The continued barrage of requests indicates that the campaign is not only necessary but effective at reaching the general public. Most recently, we were fortunate to have received requests from Ontario, Florida, Washington, and Oregon.

It is important to note that a community need not implement all of the components to have a successful pollution prevention campaign. Components can be mixed and matched to create the most useful campaign for individual situations. The success of "It's All Connected" is dependent on the willingness of communities to adopt the program. However, the real success will be realized with cleaner waters across the Nation.

Alternative Selection Through Innovative Flood Hazard Management Criteria

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Prince George's County has been involved in the preparation of Comprehensive Watershed Management Plans for the past 13 years. State-of-the-art hydrologic and hydraulic techniques are applied on a continuous basis in defining the floodplain boundary and identifying flood-prone areas. However, the diversity in development intensity, land use planning, zoning, and geographical areas within the county's 12 major watersheds do not promote an effective and consistent determination of the best flood hazard mitigative measures.

In the past, the county's policy has been skewed toward choosing acquisition as the preferred alternative for flood protection. Acquisition, though effective in eliminating the flood hazard, can be disruptive to the community and prohibitively expensive. The expense of acquisition is the overwhelming reason for the development of county-wide flood hazard management criteria referred to as the Preference Matrix.

The Preference Matrix was developed to assist in the decision-making process to determine the appropriate or preferred priority order of mitigative measures. The matrix will identify effective alternatives and possibly rule out marginally ineffective solutions. The recommended alternatives must be sensitive to site-specific constraints and individual impacts to homeowners, incorporate community concerns, include public participation, and be cost-effective.

The Preference Matrix was successfully applied to the Oxon Run watershed. One-hundred and thirty addresses under present development conditions were identified as flood-prone for 100-year storm events. Future development conditions would result in eight additional flood-prone addresses. This paper examines the best flood hazard mitigative measures for the Oxon Run watershed as identified through the use of the Preference Matrix.

The Preference Matrix

Flooding Classification

A flood-prone structure is first classified based on two factors: the *proximity* of flood-prone structures and the *severity* of flooding of a structure. Proximity denotes whether a structure is isolated or grouped moderately or extensively with other flooded structures in localized areas. The three levels within this category and the defining limits are shown below.

Proximity	Symbol	Number of Structures
Isolated	I	less than 4
Intermediate	M	Between 4 and 8
Extensive	E	More than 8

Isolated (I):	Relatively few flood-prone structures within one or more localized areas
Intermediate (M):	Moderate number of flood-prone structures within one or more localized areas
Extensive (E):	Large number of flood-prone structures within one or more localized areas

The severity of flooding for a structure is then determined for the 100-year storm event based on existing and ultimate land use conditions. The four levels within this category and the corresponding limits are shown above.

Severity of Flooding	Symbol	Depth of Flooding	
		Existing Land Use	Ultimate Land Use
Minor	min	no flooding	up to 1 foot
Limited	lim	0 to 1 foot	up to 3 feet
Significant	sig	1 to 3 feet	up to 3 feet
Extreme	xxx	0 to any depth	over 3 feet

Flooding Scenarios

While the severity of flooding is determined for each structure, the proximity is assigned by flood area. These two categories, when combined, form 12 unique flooding scenarios used to establish the priority scheme of management options.

Isolated:	I/min	I/lim	I/sig	I/xxx
Intermediate:	M/min	M/lim	M/sig	M/xxx
Extensive:	E/min	E/lim	E/sig	E/xxx

Flood Management Analysis

Next, a stepwise watershed management model was developed to establish a logical approach to alternative selection and evaluation. The following represent the steps found to be crucial to the outcome:

- Define the problem.
- Select functional constraints.
- Construct system selection criteria.
- Select alternatives to solve or minimize the problem.
- Evaluate alternatives in terms of minimizing the problem.
- Determine consequences of alternatives.
- Present alternatives.

Functional Constraints

In the analysis and selection of preventive and corrective measures for flooding problems, it is necessary to confine the alternatives within basic boundary conditions so that undesirable solutions can be eliminated. The boundary conditions are defined by the following functional constraints:

- A mitigation measure in one area of the watershed should not create a problem or exacerbate an existing problem in another area.
- The alternative should be feasible and cost-effective.
- The alternative should achieve the purpose(s) intended.
- The alternative should provide for a 50 percent or greater reduction in average annual flood damages.

Management Options

In conjunction with the unique scenarios mentioned previously, the management options must be evaluated and prioritized for each scenario. It is important to know what options are available and to understand that the priorities for ordering those options differ with changing scenarios. In an effort to consolidate the management options, the following list of options was considered.

- Structural Measures (S)
- Flood Warning (FW)
- Floodproofing (F)
- Flood Insurance (FI)
- Acquisition (A)
- Land Use Planning (L)

Structural measures considered for evaluation were flood control impoundments, levees, floodwalls, stream and floodplain relocation, stream channelization and improvement, stream enclosures, and bridge and culvert improvement. The feasibility of the nonstructural alternatives should be considered for all residential structures as well as floodproofing for nonresidential structures.

The land use planning option was eliminated from further consideration because:

- This option does not provide benefits to those structures flooded under the existing land use conditions.
- The flood management plan is also used to establish storm water management requirements for new developments.
- The land use option may be politically sensitive and controversial for "down-zoned" planning.

Priority Scheme

The remaining five options were organized into 120 different priority schemes. Flood warning and flood insurance do not eliminate the flooding and therefore should not be first in the priority scheme. Flooding problems are solved with acquisition and structural measures and, therefore, these op-

tions should not be last in the priority scheme. Finally, based on projected costs, various priority schemes were eliminated resulting in the seven schemes that follow:

- F A S FI FW
- A FI F S FW
- F S A FW FI
- S A FW FI F
- F S FW A FI
- S F FW A FI
- S A FW FI F

The Preference Matrix relates the flooding scenarios to the priority schemes. Applying the Flood Hazard Management Criteria resulted in the Preference Matrix as shown below.

Flooding Scenario	Priority Scheme
I/min	F A S FI FW
I/lim	F A S FI FW
I/sig	F A S FI FW
I/xxx	A FI F S FW
M/min	F S A FW FI
M/lim	F S A FW FI
M/sig	F S A FW FI
M/xxx	S A FW FI F
E/min	F S FW A FI
E/lim	S F FW A FI
E/sig	S F FW A FI
E/xxx	S A FW FI F

Case Studies

The criteria were first applied to the Oxon Run watershed, which has a drainage area of approximately 14 square miles and is located in one of the more highly developed areas of Prince George's County. Eleven distinct flood areas within the watershed have been identified as containing flood-prone structures. Figure 1 illustrates the entire watershed and the locations of the 11 areas. The depth of flooding was determined for each structure with the corresponding severity level. Flood areas were established based on the proximity of flood-prone structures. The combination of proximity and severity resulted in the identification of the priority scheme. The identification of the management options, in conjunction with the flooding scenarios, led to the priority schemes. The following three examples demonstrate the actual process.

Forest Heights Subdivision

Forest Heights Subdivision (Figure 2) typified the application of the Preference Matrix but also demonstrated that a geographic area could have more than one proximity. The lower portion of the subdivision contained an extensive number of flood-prone structures, while the upper portion of the subdivision identified five structures that were designated as moderate.

Lower Portion Forest Heights

Present Conditions: 42 structures with flooding depths ranging from 0.1 to 3.3 feet

Future Conditions: 44 structures with flooding depths ranging from 0.1 to 3.4 feet

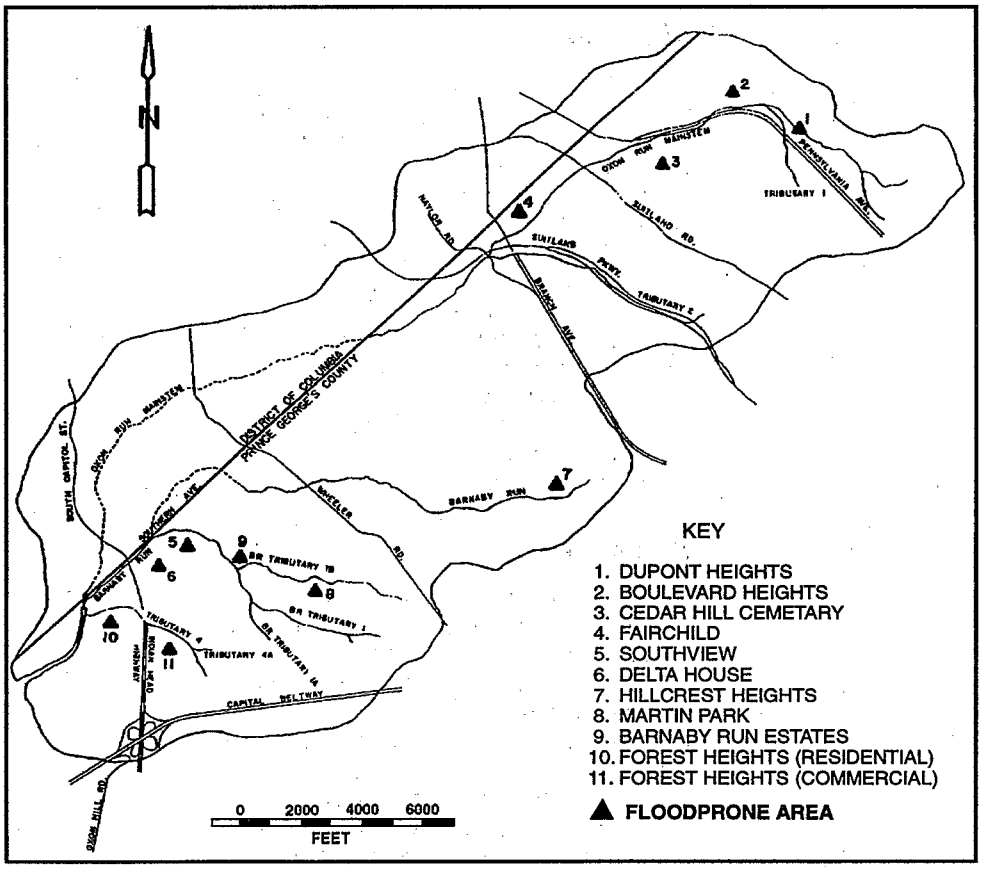

Figure 1. Residential flooding problem areas.

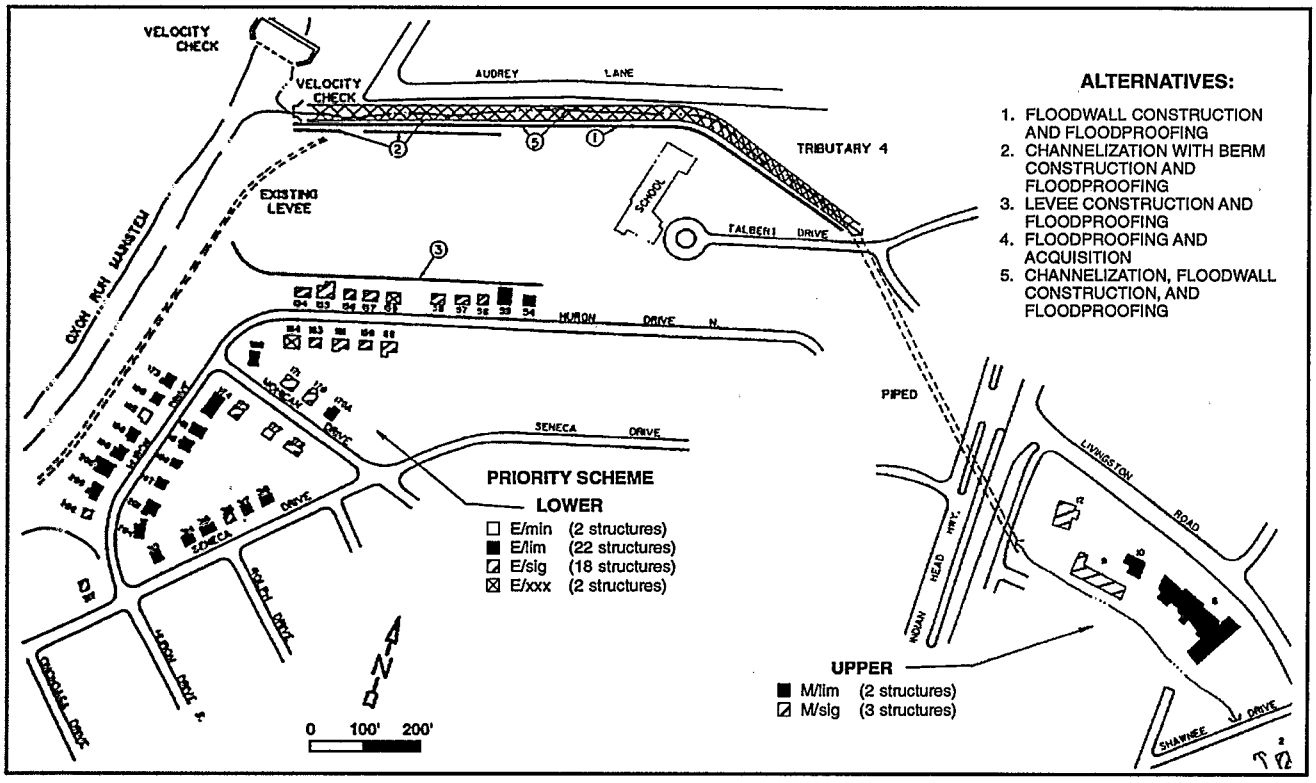

Figure 2. Forest Heights.

Flooding Scenarios: E/min (2 structures)
E/lim (22 structures)
E/sig (18 structures)
E/xxx (2 structures)

Priority Schemes: F S FW A FI (2 structures)
S F FW A FI (40 structures)
S A FW FI F (2 structures)

Actual Recommendation: The resulting priority scheme, for 42 of the 44 flood-prone structures, indicated a structural solution as the preferred alternative; therefore, stream restoration with a levee (structural) was recommended.

Upper Portion Forest Heights

Present Conditions: 5 structures with flooding depths ranging from 0.1 to 2.5 feet

Future Conditions: 5 structures with flooding depths ranging from 0.1 to 2.5 feet

Flooding Scenarios: M/min (2 structures)
M/sig (3 structures)

Priority Schemes: F S A FW FI (2 structures)
F S A FW FI (3 structures)

Actual Recommendation: The priority scheme resulted in floodproofing as the recommended alternative.

Fairfield Subdivision

The application of the Preference Matrix to the Fairfield Subdivision (Figure 3) showed that the matrix is only a guideline and that the functional constraints can eliminate or alter the management options in the resulting priority scheme:

Fairfield

Present Conditions: 5 structures with flooding depths ranging from 0.4 to 3.2 feet

Future Conditions: 5 structures with flooding depths ranging from 0.6 to 3.4 feet

Flooding Scenarios: M/lim (4 structures)
M/xxx (1 structures)

Priority Schemes: F S A FW FI (4 structures)
S A FW FI F (1 structures)

Actual Recommendation: The priority scheme for four of the five structures indicated floodproofing over a structural solution. However, consideration of functional constraints led to a recommendation to raise and extend the existing levee. The disparity was due to the cost-effectiveness of improving an existing structure over

implementing new solutions, which in this case would be floodproofing. This example showed how site-specific conditions can override the priority scheme.

Martin Park Subdivision

The Martin Park Subdivision (Figure 4) represented a direct application of the matrix to isolated structures in Oxon Run.

Martin Park

Present Conditions: 2 structures with flooding depths ranging from 0.2 to 0.7 feet

Future Conditions: 2 structures with flooding depths ranging from 0.2 to 0.7 feet

Flooding Scenarios: I/min (2 structures)

Priority Schemes: F A S FI FW (2 structures)

Actual Recommendation: Floodproofing, the preferred management option in the priority scheme, was the recommended alternative.

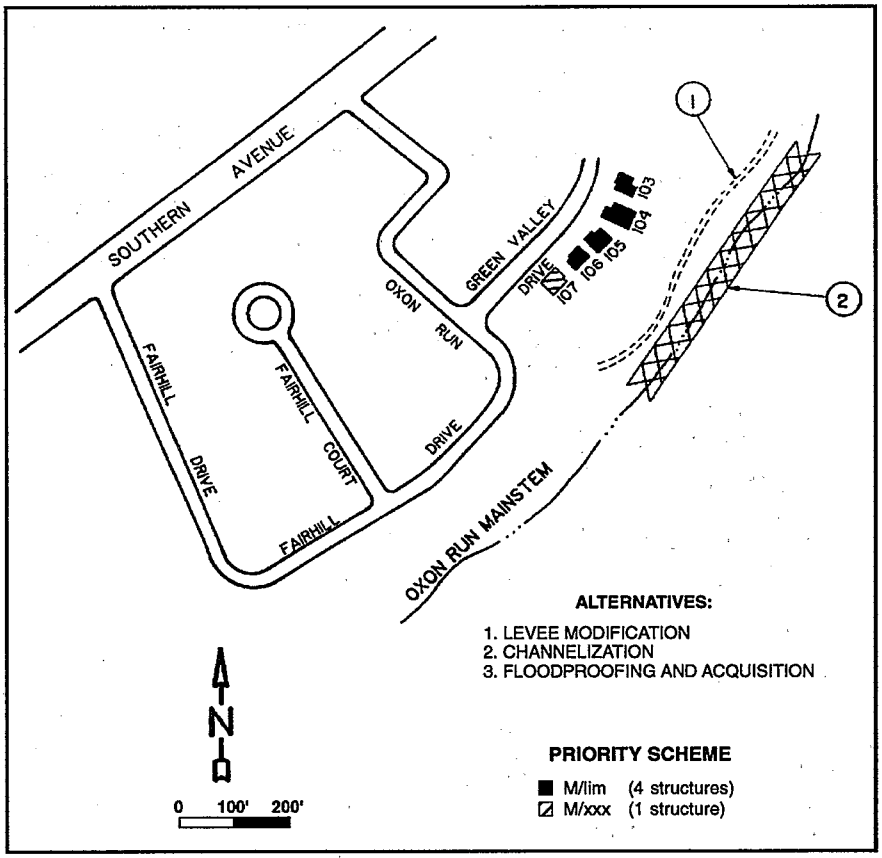

Figure 3. Fairfield.

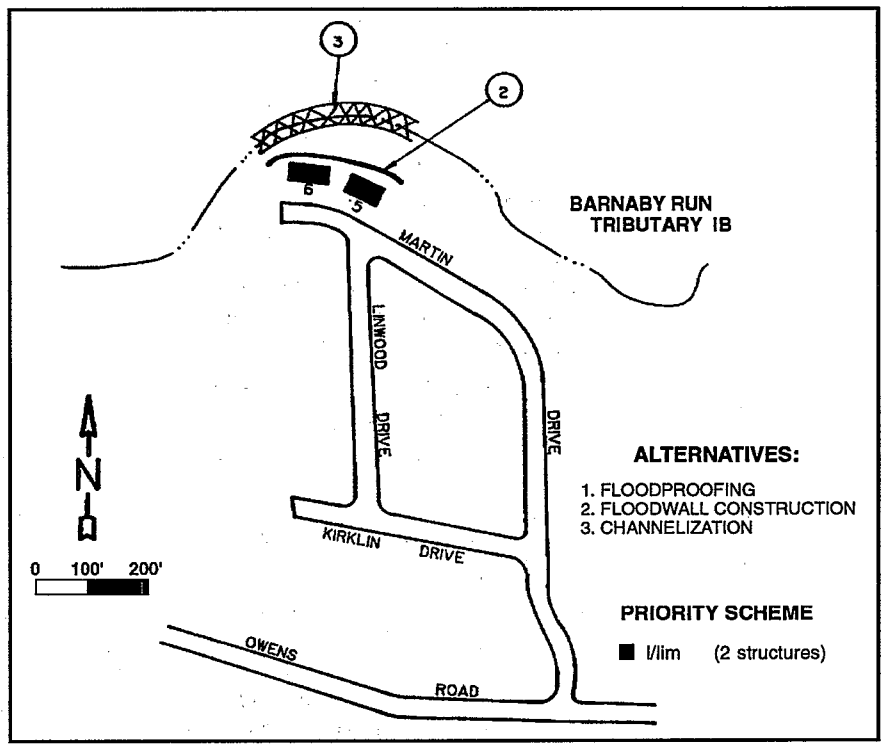

Figure 4. Martin Park.

WTRYLD: A Computer Model for Simulating Watershed Management

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The ability of a computer model to integrate complex watershed processes makes it a useful tool for analyzing the responses of a large watershed to vegetation manipulations. The model utilized in this research effort, "WTRYLD," is a predictive methodology that solves the governing equations of the physical processes of a watershed. WTRYLD simulates watershed responses to the hydrologic cycle and can be used to investigate potential water augmentation for a large watershed. The model determines whether practical increases in water production can be attained and then reclaimed downstream in a large watershed.

The watershed used in this study was the East Branch North Fork Feather River, Plumas County, CA, where Pacific Gas and Electric has a significant investment in hydroelectric generation facilities. WTRYLD was used to investigate the forest management prescriptions of clear cut, strip cut, select cut, and minimum management. Temporal snapshots of 10, 30, and 70 years of watershed management were analyzed for impacts on timing and volume of flows. WTRYLD was used to simulate the response of the watershed and allowed the user to test a variety of situations to determine changes in water yields due to vegetation management.

The traditional approach to watershed management is passive: one waits, hopes for precipitation, and observes how the watershed reacts to the incoming water. When it rains or snows, the water ultimately drains into the reservoir that holds it for future uses. Ideally, rain and snow would occur in such a way that the water would be sustained at a certain level in the reservoir; however, precipitation in California tends to be "flashy," with long dry periods punctuated by storms that put large quantities of water into the watershed. Because water represents the potential to generate electric power, it would be advantageous to find a means to alter snowpack dynamics so that melt water would enter the watershed channel system in a beneficial manner for power production, and at the same time minimize environmental impacts.

WTRYLD is an attempt to combine in one computer model all the major processes of a watershed. It was designed to simulate any watershed and can be "localized" by altering five model inputs: vegetation, soil types, watershed geometry, geographical location, and climatic data. The model provides an analytical tool to pose "what-if" questions regarding planned or unplanned events for a watershed. It is in the process of being reviewed and evaluated, and holds promise for many applications within the utility industry as well as for other private sector and governmental agencies. Some applications are analyses of cumulative effects, reservoir sedimentation, flow forecasting, and land reclamation.

Balancing Development, Water Quality, and Wetlands Protection in a Mid-Atlantic Watershed

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The Prince William County Watershed Management Division, the U.S. Environmental Protection Agency, the Corps of Engineers, Virginia universities, and other federal and state agencies are exploring methods to restore and protect water quality and wetlands in urbanizing Prince William County watersheds. A major part of the project involves examining watershed management with a cumulative and interdisciplinary vision.

Powells Creek, a Northern Virginia, Piedmont, and Coastal Plain stream just beginning to experience urbanization pressure, is the main focus of this study. Two other streams, one less developed and one more, are proposed for comparative analysis.

Project objectives include an environmental history and compilation of baseline information on water quality, land use, and terrestrial and aquatic resources. Innovative and proven methods of storm water management, from nonstructural approaches to on-site and regional storm water ponds, will be tested and evaluated. Rapid bioassessment techniques will be used in addition to conventional chemical sampling to monitor stream conditions. Design of storm water management facilities will attempt to replicate pre-development hydrologic characteristics of the watershed based on hydrologic and hydraulic models. The project is examining the cumulative impacts of how urbanization degrades water resources and how sound watershed management may mitigate water quality problems.

Imagery analysis will be used to create a historical land-use record of the Powells Creek watershed, and to look at, for example, erosion, channel degradation, and past agricultural practices. Imagery can be used to monitor watershed development in an attempt to correlate land-use patterns with environmental impacts.

The integration of geographic information systems with imagery will provide a data base that goes far beyond traditional mapping functions and can provide relational information tools that give watershed managers an interactive ability to derive information. Project-generated, annotated imagery is the foundation on which group understanding of watershed needs will be built.

The Atlantic Region Riverkeepers Project: Building Community Support for River Conservation

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Quebec-Labrador Foundation/Atlantic Center for the Environment
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The *Atlantic Region Riverkeepers Project* is a set of complementary public outreach and river conservation activities designed to stimulate greater community involvement and grassroots river conservation leadership in northern New England and eastern Canada—the "Atlantic Region." Under the Riverkeepers Project, school classes and citizens in pilot watersheds are encouraged to become better stewards of their rivers, or "riverkeepers" through:

- School-based programs and materials that address local concerns and provide teacher training in a multidisciplinary approach.
- Community-wide programs to heighten interest and participation.
- A computer-based information network and mapping to link communities and foster up-to-date resource assessment.
- Publications to document the model and provide public information.
- Leadership exchange programs to provide direct leadership development and international exposure.

The U.S. Environmental Protection Agency (EPA) selected the project for one of its 1992 National Environmental Education Grants. So far, project activities on the upper Connecticut, St. John, and Penobscot Rivers are part of the multiyear initiative:

- *St. John River.* Nature discovery programs and water quality monitoring training for area teachers and students in the upper watershed, focusing on the endangered plants and water quality; an international conference on regional conservation and economic development; linkages to the University of Michigan's Global Rivers Environmental Education Network (GREEN), and natural and cultural history publications.
- *Connecticut River.* An interdisciplinary week on rivers organized by teachers and Atlantic Center staff including water quality monitoring, visits to a fish hatchery, and computer-based simulations; public forums in sub-basin areas to provide opportunities for other citizens to discuss the future of their communities and the upper watershed.
- *Penobscot River.* A source-to-sea river expedition and community outreach project completed in spring

Photo courtesy of Elliott Gimble

Teacher and students from Allagash, Maine, testing for dissolved oxygen in the St. John River.

1993; public programs in conjunction with the expedition include festivals, flotillas, and forums with slide show. Cooperators: University of Maine Cooperative Extension Service, the University's Water Resources Institute, Maine Bound and the Penobscot Institute (a network of over 80 teachers).

Quebec-Labrador Foundation/ Atlantic Center for the Environment

The Quebec-Labrador Foundation/ Atlantic Center for the Environment is a nonprofit educational and environmental organization incorporated in both the United States and Canada. For over 30 years, the organization has worked to promote local leadership and to conserve the natural and cultural resources of rural communities in the Atlantic Region (northern New England and eastern Canada) through environmental education and research projects. The Atlantic Center's UPRIVER Program assists community-based river and land conservation organizations in assuming a greater stewardship role in the management of natural resources, through education, communication, and technical assistance.

Occurrence and Transport of Pesticides in the Mississippi River Basin

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The Mississippi River basin contains the largest and most intensive agricultural region in the Nation. Large amounts of pesticides (herbicides, insecticides, and fungicides) are used in order to increase yields from the major crops grown in the basin (corn, soybeans, sorghum, wheat). About two-thirds of all pesticides used annually for agriculture in the United States are applied to cropland and pasture land in the Mississippi River basin. Herbicides account for about three-fourths of the annual pesticide use and are the most frequently detected pesticides in streams throughout the basin.

Recent regional-scale studies by the U.S. Geological Survey have shown that significant amounts of herbicides are flushed into streams by late spring and summer rainfall following application of herbicides to cropland. These amounts are large enough to produce high concentrations of several herbicides in streams for a few weeks to several months during periods of storm runoff. Concentrations of herbicides in some small streams may briefly exceed 50 µg/l, and annual average concentrations may exceed drinking water standards established under the Safe Drinking Water Act. Flow from these small streams, in turn, transports significant amounts of pesticides into large rivers such as the Missouri, Ohio, and Mississippi, and eventually to the Gulf of Mexico. During 1991 and 1992, 28 pesticides and pesticide degradation products were detected in the main stem of the Mississippi River, although most of these were detected in very low concentrations (less than 0.5 µg/l). Maximum concentrations of the most extensively used herbicides such as alachlor, atrazine, cyanazine, and metolachlor, in the Missouri, Ohio, and Mississippi rivers ranged from 3 to 10 µg/l and exceeded health-based limits for drinking water for periods as long as one month at some locations. However, the annual average herbicide concentrations in these large rivers were far below health-based limits, and concentrations did not violate the Safe Drinking Water Act. Low concentrations (0.005 to 0.2 µg/l) of atrazine, cyanazine, and metolachlor were detected throughout the year in the Mississippi River due, in part, to storage and subsequent discharge of these compounds from lakes, reservoirs, and aquifers.

The total mass of pesticides discharged annually from the Mississippi River represents a small fraction of the total amounts applied to cropland in the basin. The atrazine and cyanazine discharged to the Gulf of Mexico, April 1991 through March 1992, was equivalent to about 1.6 percent of the amounts applied annually in the basin. The quantities of several other herbicides discharged annually from the basin, expressed as a percent of the amount applied, were: metolachlor, 0.8 percent; alachlor, 0.2 percent; and simazine, 2.7 percent. Most of the herbicide transport occurs during May, June, and July. More than one-half of the total quantity of pesticides transported annually by the Mississippi River originates in small streams draining from Iowa, Illinois, and parts of Missouri and Minnesota, an area that constitutes only about 22 percent of the Mississippi River drainage basin.

The Pawcatuck Watershed Education Program

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The Pawcatuck River watershed is currently targeted as one of many across the Nation receiving federal funds to study factors affecting water quality. This watershed is designated as a sole source aquifer, with ground water being the only available source of high-quality drinking water for the citizens in the area. Ensuring continued appreciation of and protection for this watershed is of utmost concern to all.

The Southern Rhode Island Conservation District, in cooperation with the Soil Conservation Service and University of Rhode Island, has developed an educational curriculum about the watershed to heighten awareness and support for the protection of water resources in the area. This interactive curriculum, entitled the "Pawcatuck Watershed Education Program," is written for the fourth through eighth grade levels. It includes nine classroom sessions combined with four field trips and over 100 hands-on activities. Examples of the sessions include topics such as *What Is a Watershed, Wetland Ecology, Land Use Effects on a Watershed, What Is an Environmental Issue*, and *Public Hearing and Citizen Action: A Final Look.* Students select a current issue, such as a local development proposal, for discussion and debate in the final session. Students play the roles of various interest groups concerned with the development proposal, and then vote whether or not to allow the development to occur. Through this investigation and role play, students learn how to make balanced, educated decisions about environmental issues affecting the community and watershed in which they live.

This curriculum can be adapted to any watershed nationwide; the principles remain the same. The curriculum has been piloted in two sixth-grade classrooms and was recently selected as the environmental education "curriculum of choice" for private and parochial schools in Rhode Island. In addition, the use of the curriculum has led to an increased knowledge of and interest in all water quality activities in the Southern Rhode Island Conservation District. This curriculum can be used nationally as an effective medium for public outreach and to build support for local watershed management activities.

A Watershed-Oriented PC Data Base for Managing Land Use and Pollutant Data in the Albemarle/Pamlico Drainage

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In recent years, the North Carolina's Albemarle and Pamlico (A/P) basins have been experiencing a variety of environmental problems. These problems include declining populations of submerged aquatic vegetation, decreasing shellfish yields, increased turbidity, skin and shell diseases on aquatic organisms, and algal blooms. In response to these problems, the A/P basin system was designated as an estuary of national significance in 1986 and was selected for study as part of EPA's National Estuary Program. The resulting Albemarle/Pamlico Estuarine Study was initiated as a cooperative program between the U.S. Environmental Protection Agency and the State of North Carolina's Department of Environment, Health, and Natural Resources.

As part of the A/P Study, Research Triangle Institute has developed a prototype PC-based data base for managing land use and pollutant data at the *watershed* level. The data base contains a wide range of information such as point and nonpoint nutrient loadings, production data for major crops, livestock inventories, and levels of BMP implementation. The system fills a unique niche by providing multi-parameter watershed data at the PC level. Previously, such information was distributed among various agencies and existed in multiple forms and levels of spatial aggregation. A user-friendly front end to the data base allows users to generate watershed-level reports and rank all watersheds in the study area based on any given parameter (e.g., density of chickens, area of corn planted, etc.). The system includes normalized data values (per square kilometer) in order to facilitate comparisons between watersheds.

Presenting a Water Quality Control Plan in an Electronic Format

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The nine California Regional Water Quality Control Boards have developed Water Quality Control Plans (Basin Plans) for their respective regions. The purpose of these plans is to list beneficial uses and water quality objectives for waterbodies within each region. Beneficial uses describe what use the water may have, such as drinking water supply. Water quality objectives are limits for various parameters (e.g., nitrates, pH) that are expected to protect the beneficial use of the waterbody. These values are the basis for permit discharge limits.

In its present paper form, our Basin Plan is like a reference manual that one can use to determine discharge limits or what beneficial uses a waterbody has. It is indispensable as a watershed planning tool because, for example, numeric objectives can be used in a modeling program or beneficial use information can be used to assess and rank the threat to water quality of a lake.

While the utility of the Basin Plan cannot be questioned, it has some limitations. For instance, to put the information into a report, it must be retyped. This introduces the chance for transcription errors. As another example, you must look through several sections of the Basin Plan to determine what the beneficial uses and objectives are for a particular ground-water sub-basin.

Electronic text is rapidly becoming popular as a mode for presenting written information. Disks take up much less room than paper documents. CD-ROMs are virtually indestructible, and the stored information cannot be changed. If the person "reading" the document has a utility available that can extract text from the screen and put it into another document, transcription errors could be eliminated.

To demonstrate how electronic text can be useful, I have taken excerpts from our current Basin Plan. A hypertext format was chosen because it highlights the most important information, allowing access to supplemental material. Furthermore, it permits a person to read at his or her level of understanding (e.g., reading the chemical names or their formulas). The information is also arranged in a more logical manner. Going back to the previous example of looking up information related to a particular ground-water sub-basin, all the reader has to do is select the map of the main basin, select the ground-water sub-basin, and open the link. A screen would appear that summarizes the beneficial uses and standard water quality objectives for that particular basin, with options to read more. Abbreviations and acronyms could be spelled out.

Evaluation for Planned Wetlands: An Approach to Assessing Replacement of Wetland Functions

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Wetlands continue to be impacted, and the losses are mitigated through wetland replacement, i.e., wetland construction, restoration, or enhancement. As wetland replacement has become more commonplace, it has become clear that the simple acre-for-acre compensation is inadequate and that future efforts must focus on replacement of wetland functions. An assessment and a comparison of functions in the wetland to be impacted and the replacement wetland are now considered fundamental to the wetland replacement (mitigation) process. To meet this need, Environmental Concern, Inc. developed Evaluation for Planned Wetlands (EPW), formerly the Wetland Replacement Evaluation Procedure (WREP). EPW provides a method by which to determine whether plans for a replacement wetland have been designed to compensate for functions lost in the wetland to be impacted.

EPW may be used in any context involving wetland replacement, including during the section 404 permit review process. It is a simple procedure that documents and highlights differences between wetlands based on their capacity to provide six functions entitled:

- Shoreline bank erosion control.
- Sediment stabilization.
- Water quality.
- Wildlife.
- Fish (tidal, nontidal stream/river, and nontidal pond/lake).
- Uniqueness/heritage.

The differences between wetlands are expressed in terms of individual elements, Functional Capacity Indices, and Functional Capacity Units. The EPW manual includes detailed directions on how to perform the procedure, supporting documentation with a literature-based rationale, and a discussion on the application of EPW to the section 404 mitigation process. Preliminary use of EPW on mitigation projects has shown that it is relatively rapid and provides consistent results.

Cooperative Extension Service National Water Quality Information Management Project Bibliography and Data Base

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The National Water Quality Information Management Project is the result of a cooperative agreement between the USDA Extension Service and Purdue University. It includes a bibliography of over 1800 water quality educational materials, produced by the Extension Service, and a data base available through the Internet or via modem. The data base includes the full bibliography as well as nearly 200 full-text documents.

The bibliography and data base allow users to search for Extension-generated publications, fact sheets, computer software, and visuals on the subject of water quality. Categories include conservation, drinking water quality, pest management, nutrient management, wells, testing, and waste management. The bibliography is further subdivided into subcategories to make searching easier. It is available from Purdue University Media Distribution Center at a cost of $10.

To login to use the National Water Quality Information Management Database via the Internet, type:

telnet hermes.ecn.purdue.edu

The login is **cerf** and the password is **purdue.**

To gain access to the National Water Quality Database via dial-up connections, the phone number is:

317-494-8350

The login is **cerf** and the password is **demo.**

Once you have completed login, follow the directions for the Internet access.

From Grass Roots to Brass Tacks: Nontraditional Approaches to Public Involvement in the Lower Colorado River Watershed

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In 1934, the Texas Legislature created the Lower Colorado River Authority (LCRA), a conservation and reclamation agency known as the "Texas TVA." LCRA's district encompasses 10 counties in the lower Colorado River watershed in central and south central Texas. Along with flood control, power generation, and water supply, LCRA's primary responsibilities include land, water, and wildlife resource protection and management. Unlike most public agencies, LCRA cannot tax and does not receive tax money. Instead, like a private business, it must rely on revenue—primarily from the sale of electricity and water—to fund its operations.

LCRA developed four high-profile programs to expand the public's awareness and understanding of the river and to rally public support for water quality measures.

The *Colorado River Trail Explorer's Map* highlights the watershed's culture, history, recreation, agriculture, and natural environment. The tourism map draws people to cities and attractions in the river corridor. Once there, it focuses their attention on how the river formed and maintains the watershed's societal fabric. LCRA helped private citizens, community leaders, and elected officials create the map using input from 32 public workshops. Since October 1992, LCRA and its partners have distributed more than 30,000 copies of the map.

Adopt-the-Colorado River brings people to the river and challenges them to think about it and the watershed in new ways. To accomplish this, the program uses floattrips, river surveys, and targeted cleanups. It revitalized the "chautauqua," an old fashioned campground meeting featuring entertainment and education. In 1992, LCRA sponsored 12 public clean-up days along 50 miles of river and held two chautauquas that involved more than 1,000 participants.

LCRA's *Creekside Conservation Program* provides technical advice and cost-sharing to reclaim private land and decrease erosion. Demonstration projects target critical locations in the watershed where sedimentation is greatest. They apply cost-effective erosion control and land management practices. In the last 3 years, local soil and water conservation boards selected 40 participants for the program and LCRA and landowners treated 8,314 acres in five counties.

The *Colorado River Watch Network* (CRWN) monitors and analyzes water quality throughout the river basin. CRWN grew from a few students in 1988 to more than 500 volunteers in 1993. The Network was responsible for the adoption of phosphate detergent ordinances in four cities and for creating water quality testing technology. The program received the 1992 U.S. Environmental Protection Agency's Region VI Environmental Excellence Award in Education.

Reaching an Urban Audience: Using Mass Media to Enhance Nonpoint Source Pollution Prevention

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Looking for innovative mass media ideas for your public information program? Thinking about developing a state, regional, or local nonpoint source (NPS) pollution prevention initiative? In 1990, the Dane County, WI, Lakes and Watershed Commission initiated a comprehensive public information and education campaign to increase public awareness and understanding of NPS pollution issues. The campaign, dubbed *Dane County WaterWatch*, grew out of a strategic plan that identified several formal and informal communication formats, including a mass media initiative. Local authorities determined that a mass media campaign would be the most effective way to promote an NPS pollution prevention message to the residents of urban and urbanizing communities. Urban nonpoint sources are significant because the greater Madison metropolitan area has developed along the shores of several lakes, all of which are classified as eutrophic. In addition, Dane County was the fastest growing county in the state during the 1980s with most of this growth occurring within cities and villages.

The *WaterWatch* campaign has employed several mass media techniques to inform area residents about NPS pollution and to provide prevention messages. Products developed for the campaign include a slogan, logo, mascot and radio tag, award-winning radio and television public service announcements, and an outdoor message. The most recent product, a 24-minute video entitled *In Current Repair*, takes a fast-paced, humorous look at ways in which individuals can help to reduce polluted runoff. The county has retained an advertising and marketing firm to assist in the implementation of the campaign. This paper will review the *WaterWatch* campaign strategy, the public opinion and behavior study behind *WaterWatch*, and the products developed for the campaign.

Background

Dane County, Wisconsin

Located in south central Wisconsin, Dane County is home to over 360,000 residents. The 1990 census revealed that the county grew by more than 13.5 percent (43,000 residents) during the 1980s—faster than any other Wisconsin county. Current predictions estimate that the county can expect similar growth into the next century. Madison, located in the center of the county, is the state capital, county seat, and home to the University of Wisconsin-Madison. Government is the major employer with financial, technical, and health service sectors also contributing to the local economy. The county ranks among the Nation's top 10 counties in value of farm products produced. About 80 percent of the county's approximate 1,200 square miles is agricultural land.

*Currently with the Nonpoint Pollution Program in the Wisconsin Department of Natural Resources. For information about the *WaterWatch* program, contact John Exo, Dane County Lakes and Watershed Division.

The Lakes and Watershed Commission

In an effort to address the fragmentation of watershed management authority in the area, the Dane County Lakes and Watershed Commission was created in July 1988. In April 1990, the Commission's composition, duties, powers, and organization were further defined and formalized through state legislation. The statute directed the Commission to improve water quality and the scenic, economic, recreational, and environmental value of the county's water resources. The Commission has determined that public information and education play a critical role in fulfilling this mandate. The Watershed Management Coordinator is responsible for coordinating a county-wide informational campaign.

County Water Resources

Dane County contains 64 lakes (20,750 acres), 109 streams (2,212 acres), and 166 farm ponds (138 acres) (DNR, 1985). Four river basins make up the county's 1,200 square miles: the Yahara River drainage basin (38 percent); the Sugar-Pecatonica River basin (22 percent); the Koshkonong Creek-Maunesha River basin (22 percent); and the Wisconsin River basin (18 percent) (DCRPC, 1992). The greater Madison metropolitan area sits adjacent to Lakes Mendota and Monona, two of the four Yahara River lakes, all of which are classified as eutrophic.

Nonpoint source pollution from agricultural, urban, and urbanizing lands is the primary water quality concern in the county. The most significant point source of pollution is effluent discharged from municipal sewage treatment plants. Discharge of sewage to the Yahara lakes ceased in 1971 when Madison area wastewater discharge was diverted to Badfish Creek, a small stream south of Madison.

According to *Water Quality in Dane County* (DCRPC, 1992), 10 of the 16 stream monitoring stations in the county have high bacteria levels, low dissolved oxygen concentrations, or poor biotic/habitat conditions. Lakes Monona and Waubesa contain bottom sediments contaminated with metals and PCBs; large walleyes from these lakes appear on the Wisconsin Fish Consumption Health Advisory List. Approximately one-third of the private, shallow wells tested in the county exceed the recommended public drinking water standard for nitrates. Common agricultural pesticides have been detected in half the rural wells tested.

The Strategy Behind the *WaterWatch* Campaign

In the summer of 1989, the Commission requested proposals to develop a strategic plan for the information and education campaign. In September of that year, Wood Communications Group was retained to develop the strategy. The firm completed its final report, *A Strategic Plan for Public Information and Education Activities Related to Lakes and Watershed Issues in Dane County*, in November 1989. The report defined the objectives, target audience, message, and campaign design that could be used in the Commission's information and education campaign.

The Objectives

The plan is designed to achieve five objectives:

- Develop a public constituency in support of Dane County's efforts to improve and protect water quality in the county.
- Inform and educate the general public about what affects water quality in the county.
- Inform and educate the general public about the relationship between their actions and water quality in the county.
- Inform and educate the public about what they can do individually and collectively to reduce sedimentation and nutrient and chemical loadings to surface water in the county.
- Reduce sediment and nutrient loadings in the county.

The Target

Unlike most persuasive campaigns undertaken by marketing firms, the Dane County Lakes and Watershed Commission message must be directed at nearly every person in the area. The plan suggested that the Commission avoid the geographic (urban versus rural), occupational (industrial versus agricultural versus residential), and general "source of problem" nomenclature

commonly used when discussing pollution. Such terminology, the plan reported, would only serve to reinforce the "point source villain" mentality and in so doing would be more likely to encourage finger-pointing and confrontation. The target population, then, was determined to be Dane County residents. The plan suggested that certain sub-populations of this overall group should be addressed through more focused communication channels. Agricultural newsletters, for example, could discuss feedlot runoff concerns or neighborhood associations could host meetings on alternative lawn care.

The Message

Because the campaign sets out to change beliefs and, in turn, behavior, the plan made a number of suggestions regarding the campaign theme and message. These suggestions included:

- The theme and message must appeal to values that are at least as strong as the prevailing beliefs that must be changed. Pride, self-worth, responsibility, and self-interest should be targeted.
- The central theme must be broad enough to appeal to the generic targeted population, but flexible enough to allow for the adaptations required by communication channels and programmatic requirements.
- The theme and messages must both encourage support for the program and stimulate actions which will improve water quality.

The Campaign

The strategic plan is based on the idea that public attitudes and beliefs must be changed before we can expect changes in polluting behavior. The strategy appeals to the belief that one person should and can make a contribution to the health of our water resources. Information, when transmitted effectively, can affect beliefs and, in turn, transform behavior. The strategic plan is structured to allow the campaign to make use of many forms of communication, both formal (i.e., television) and informal (i.e., neighborhood meetings).

The plan detailed six campaign initiatives: mass media, non-mass media, special events, fundraising, organizational, and evaluation. The plan advanced a set of goals for each initiative and proposed a possible administrative framework for their implementation. For example, it was recommended that the mass media initiative:

- Lay the broad conceptual foundation of the campaign.
- Reinforce positive behavior.
- Enhance public awareness of the issues and transmit timely information.
- Provide a vehicle for involving other constituencies in the campaign.

Putting the Initiatives into Action

The strategic plan also proposed avenues for implementing each of the six initiatives. Actual product development has varied over time depending on program resources, complementary activities in other programs, and community and media interest.

The Mass Media Initiative

Designed to maximize local media outlets, this initiative emphasizes public service announcements, news broadcasts and newspaper coverage, and local talk shows.

The Non-Mass Media Initiative

Contributions to trade journals, newsletters, and special interest magazines, presentations before civic and professional organizations, and participation in informal community gatherings (e.g., fairs, parades) provide additional means for delivering the campaign message.

The Organizational Initiative

Purposefully incorporating community organization involvement in elements of the campaign serves to build long-term community support for nonpoint source pollution prevention measures.

The Special Events Initiative

The campaign can draw attention to specific problems and necessary actions by hosting special events in the community. These events should also incorporate techniques to attract media attention.

The Fundraising Initiative

The strategic plan recommended that *WaterWatch* pursue funding opportunities including major contributors, general campaign sponsorship, special events sponsorship, community fundraising, and in-kind contributions.

The Evaluation Initiative

Periodic surveys were recommended to determine the extent to which the campaign messages were received by the community.

Establish Baseline Data on Attitudes and Beliefs

In 1990, the Commission contracted with Wood Communications Group to conduct an initial survey as part of the strategic plan's evaluation initiative. Wood surveyed area residents in order to establish a benchmark against which future surveys could be compared. The survey was designed to measure the respondents' opinions and behaviors related to water quality. This work provided the Commission with a snapshot of respondents' use of Dane County surface waters, attitudes about sources of water quality problems, attitudes about effective action, and views on individual responsibility for reducing nonpoint source pollution.

Telephone interviews were conducted with randomly designated adult respondents in 400 households using a random digit dial telephone sample of all telephone exchanges and banks in operation within the county. Further information on the survey method can be found in the report *A Look at Dane County's Lakes and Streams: A Report of a Survey of Dane County Residents.*

The results of the study indicate that nearly all residents use county lakes and streams in some fashion. About one-third of the respondents avoid one or more of these resources out of concern about water quality (e.g., "weeds," algae, murky water). A majority of respondents accept water quality issues as important relative to other issues facing the county. Respondents typically attribute water quality problems to home lawn care products, industrial and manufacturing waste, runoff from streets and highways, and agricultural erosion. Overall, the survey revealed that while there is near consensus about the importance of protecting our waterways, there is little agreement about what should be done and whose responsibility it should be to do it.

WaterWatch: The Mass Media Initiative

In 1990, the Commission retained Knupp and Watson Advertising and Marketing to implement the mass media initiative. While following the general concepts contained in the strategic plan, the firm has adapted the plan to maximize the strengths of its staff and other resources. The initiative has yielded numerous products.

- *Name.* The name "Dane County WaterWatch" links the campaign to water and reflects the Commission's goal of encouraging people to watch their day-to-day behavior.
- *Logo.* The logo, a timepiece inside a water drop, illustrates the notion of water and time. In effect the logo tells us: the time to act is now. The logo is also linked to the campaign name by the "watch" element.
- *Slogan/Theme.* The slogan, "Make Your Drop Count," was developed to appeal to the notion that every person needs to pitch in and that our behavioral changes—our drops in the bucket—will add up to collective action aimed at protecting water quality. The Commission felt strongly that Dane County residents had to learn how their behavior influences water quality before they would adopt new actions. The slogan aimed to encourage individual responsibility and respect for area water resources without pointing fingers at those who are at fault. Over time, however, it became apparent that many people confused the message with water conservation. As a result, we began to use a new slogan, "You're the solution to water pollution," that had originally been designed for an outdoor public service message. This message more clearly signals that water *quality* is the issue.
- *Characters.* As part of the *WaterWatch* campaign, Dane County has acquired two characters, Papa Drop and Droplet. Papa Drop is an 8-foot-tall water drop; his

granddaughter, Droplet, is somewhat smaller. The characters were purposefully designed to depict a male and a female character from two generations. The water drops are used to personalize water quality issues and educate younger residents. They represent the Dane County Lakes and Watershed Commission at various events throughout the area, including innumerable parades, festivals, and fairs. In addition, the Drops visit with hundreds of elementary school children throughout the year. During these visits they illustrate—using self-sticking fabric pollutants—how storm water transports common pollutants from our yards and streets to area waterways.

- *Video Public Service Announcements.* Three public service announcements (PSAs) have been developed to date for the mass media initiative of the WaterWatch campaign. *Leaves* is a sprightly and informational video which quickly alerts viewers to the problems leaves can bring to a waterbody. By stressing that individual actions influence water quality, the award-winning *Dump Truck* encourages viewers not to "dump the blame" for area water quality problems. *Gutter* uses strong visuals to show how storm sewers make every urban land parcel waterfront property. Every year the PSAs are rereleased to area stations.
- *Radio Public Service Announcements.* Two prerecorded radio PSAs were developed to parallel the messages promoted in the *Dump Truck* and *Gutter* video PSAs.
- *Outdoor Public Service Message.* In 1992, a local firm donated the use of two dozen billboards in the Madison metro area. A water quality message, "You're the solution to water pollution," was developed and run over several months. In-kind donations of this type are an important part of our campaign.
- *Long-Form Video.* In an effort to provide county residents with more detailed instruction on water-friendly behaviors, we developed a 24-minute long-form video in 1992. Although not originally designed to be a mass media product, *In Current Repair* has run on area community cable access stations. The video takes a fast-paced, humorous look at nonpoint source pollution, with topics that include how sediment and nutrients influence water quality; alternative lawn care; pet waste disposal; construction site erosion control; agricultural best management practices; and citizen involvement activities.
- *Brochures.* Widely distributed at fairs, meetings, and parades, the WaterWatch brochures inform readers of the WaterWatch campaign, our mascots, and how individuals can change their behavior to benefit area water resources. The brochures have served to improve recognition of the Commission and the mascots as well as to provide basic water quality tips to readers. When coupled with a counter display, the brochures become an effective and attractive educational device for retail outlets and government offices.

Funding *WaterWatch*

Dane County officials are committed to the idea of a strong information and education effort. To date, $109,500 has been authorized to implement the WaterWatch mass media initiative. Through the use of an advertising and marketing agency with excellent state and local media contacts, the county has

Years	Products	Cost
1989	Name	$35,000
1990	Logo Slogan	
	Audio Tag	
	Characters	
	Costumes	
	Brochure	
	Video PSAs 1,2	
1991	Video PSA 3	$49,500
1992	Rerelease PSAs	
	Radio PSAs	
	Outdoor message	
	Video	
1993	New costumes	$24,500
	Counter cards	
	Brochures (5)	
	Rerelease PSAs	

benefited from a significant quantity of donated services, with an estimated worth of $20,000-30,000. These in-kind donations have allowed us to stretch annual funds to produce an ambitious set of products. Production cost of our public service announcements, for example, have run as high as $6,500 with up to $2,000 in additional donated in-kind services.

Some Tips on Working with an Agency

For those of us accustomed to crafting fact sheets and press releases, a mass media campaign opens up a world of professional opportunities. Working with an advertising and marketing agency can be an exciting experience. You may find it useful, however, to keep in mind the following points:

- Work with an agency or contractor that understands the big picture of mass media and is well tied into the local marketing arena. Select an agency that recognizes the usefulness of strategic planning—but also is well aware of the realities of the competitive media marketplace.
- Agency staff don't know the difference between point and nonpoint source pollution? Don't give up. Remember: you're hiring experts in marketing, not phytoplankton or sediment transport. Personal interest in water resources can be a real benefit, however, in keeping the creative fires kindled.
- An agency experienced in public information campaigns could be a real bonus. Knupp and Watson, for example, had worked on the Wisconsin Department of Transportation's Adopt-A-Highway campaign.
- After some initial brainstorming, be decisive and clear in your goals and directions. Be careful not to burden agency staff with unnecessary details. Focus their efforts on big productions and media contacts. Remember that time really is money.
- Keep in mind that you are not the driving creative force behind the products. The agency's creative staff get paid to generate a concept and look for a product. If you are uncomfortable with risk or new ideas, you may find this process uncomfortable. Relax and give agency staff a chance to sell their work. If you remain unconvinced and uncomfortable, bounce the product off others who have not been involved in the project. Disqualify anyone with whom you have discussed your doubts or concerns. If the product misses the mark, be clear about your concerns and remain reasonable in your requests to rework the product.

Other Public Information and Education Efforts

Take a Stake in the Lakes

Each year, the Dane County Lakes and Watershed Commission sponsors a special event designed to involve Dane County residents in cleaning the shores of the four Yahara Lakes. Since its inception during the summer of 1988, it has provided an attractive outlet for people who want to have a positive impact on their local environment. The event augments existing aquatic plant management efforts by the county as Take a Stake volunteers rake and remove aquatic weeds along the shorelines and collect and dispose of other debris littering these areas. The event is promoted through extensive contact with potential volunteer groups as well as television and radio interviews, announcements, posters, and brochures.

Better Lawns and Gutters

Better Lawns and Gutters is a homeowners guide to protecting water quality. This piece was developed by the Dane County Extension, the Nutrient Pest Management Program of the University of Wisconsin, the Dane County Regional Planning Commission, and the Yahara-Monona Priority Watershed Project (sponsored by the state Department of Natural Resources) with the assistance of Lakes and Watershed staff. The guide has won numerous state and national awards and is chock full of basic information, helpful hints, and colorful graphics.

Lawn Care Demonstration Days

The Yahara-Monona Priority Watershed project staffed out of the Lakes and Watershed Division sponsored a walking tour of water-friendly home lawn care

practices. Another tour for homes and businesses will be held in July 1993.

Storm Sewer Stenciling

Dane County initiated a storm sewer stenciling program in 1990. The county provides kits to interested groups and citizens free of charge.

Signs of Success

This program, begun in 1992, is designed to reward "water-friendly" behavior and to encourage others to adopt this behavior so that they too may be recognized in their community. Neighborhood associations, youth groups, and schools are the target participants. Each group must complete a specified number of criteria in two categories—learning and doing—and agree to comply with the program guidelines. In return, Lakes and Watershed staff will provide speakers, information on topics of interest, storm sewer stenciling equipment, and a reward.

Dane County WaterWatchers

Often the best way to learn about water resources is to get your feet wet. The Dane County WaterWatchers program encourages citizen involvement in stream monitoring and habitat improvement through training sessions, special events, and a series of guidebooks.

Acknowledgments

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Integrated McKenzie Watershed Management Program

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The McKenzie River in Oregon flows from the crest of the Cascade mountains westward to join the Willamette River near the Eugene-Springfield metropolitan region. With headwaters in three wilderness areas, the McKenzie contains some of the cleanest water in America. This magnificent river provides a multitude of benefits, including drinking water for over 200,000 Lane County residents, outstanding fisheries, hydroelectric generation facilities, recreation, open space, wildlife habitat, and rich soils that support the production of timber and agricultural goods. The Willamette National Forest is the largest single landowner in the 1,300-square-mile basin. The Bureau of Land Management also has major land holdings as do several major timber companies. There are many small private land holdings in the lower valley, especially adjacent to the river.

The Integrated McKenzie Watershed Management Program will study the success of taking a proactive approach to resolving problems and conflicts in the basin based on active citizen participation. The Program will also develop a workable and transferable model for natural resource protection. During the past year, the Eugene Water & Electric Board and Lane County met with numerous affected state agencies to coordinate the study's early phases and to gather further support.

In fiscal year 1993, EPA funds were appropriated to begin this 3- to 4-year study and, with the cooperation of several federal agencies and state and local governments, work was begun to establish the Watershed Council—a forum to make basinwide resource decisions. The Council will have about 15 members, half citizens and half elected officials and agency representatives. Several products of the project will be a Watershed Council decision-making model, an integrated computer Geographic Data System for the basin, an action program, and a set of ground rules for joint decision making.

A citizen involvement process will be ongoing throughout the project. Newsletters, citizen representation on committees, field trips, high school stewardship, and other involvement activities will take place over the next 3 to 4 years as the Watershed Council develops the program. Public education will be an integral part of this process, as well as a significant product. This component will include a variety of techniques such as community forums, teacher's curricula, and participation in local interpretive centers.

Watershed Protection—Tried and True: The U.S. Environmental Protection Agency's Clean Lakes Program

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The U.S. Environmental Protection Agency (EPA) recently established the Watershed Protection Approach as a fundamental basis for the Agency's efforts to protect water resources. The key elements of this approach are:

1. The formation of *partnerships* between the people with an interest in the watershed.
2. To jointly *identify the problems* and search for consensus on the actions to be taken.
3. To *implement those actions in an integrated fashion.*

Although recently formalized by EPA, this is not a new way of doing business—it's a tried and true way of doing business, as demonstrated by the 17-year evolution of the Clean Lakes Program.

The Clean Lakes Program began in 1975 with a focus on research, development of lake restoration techniques, and evaluation of lake conditions. By 1980, it was clear that lake restoration techniques exist and that their effectiveness is dependent on the control of pollution from the watershed—primarily nonpoint source pollution.

In 1980, the Clean Lakes Program Regulations (40 CFR 35 Subpart H) outlined the types of financial assistance available to states and established the structure of the program. Today, those regulations also provide the framework for implementing the recently formalized Watershed Protection Approach for restoring and protecting lake resources.

The four types of cooperative agreements available under the Clean Lakes Program and their relationship to the Watershed Protection Approach are:

- *Phase I, Diagnostic/Feasibility Study.* This two-part study analyzes a lake's condition and determines the causes of that condition, then evaluates solutions and recommends the most feasible procedures to restore and protect lake water quality. This study provides the mechanism to identify all the parties with an interest in the lake and to bring them together to jointly identify problems and reach consensus on the actions to be taken to correct the problems.
- *Phase II, Restoration and Protection Implementation.* Translating Phase I recommendations into action, Phase II projects implement in-lake restoration work as well as critical watershed management activities to control nonpoint source pollution. These projects require the integration of many federal, state, and local activities and interests to ensure a

comprehensive attack on the problems.

- *Phase III, Post-Restoration Monitoring Study.* Phase III studies evaluate various in-lake and watershed management activities to determine their long-term effectiveness. These studies serve to answer numerous questions about individual lake techniques and watershed practices as well as about how well an integrated approach has restored and protected an aquatic resource.
- *Lake Water Quality Assessment.* These cooperative agreements assist the states and qualified Native American tribes in conducting statewide or reservation-wide assessments of the condition of their publicly owned lakes and help support state or tribal lake programs. Many states use these funds for volunteer citizen monitoring programs and to increase public awareness of nonpoint source pollution and its effects on lakes. An involved and informed citizenry is critical for reaching consensus on the actions to be taken to protect aquatic resources and for implementing those actions.

Critical to the success of the Watershed Protection Approach and the Clean Lakes Program is the formation of federal-state-local partnerships. The formation of these partnerships requires substantial involvement and commitment from all members—especially the local communities where many of the pollution control measures need to be implemented. To ensure the involvement of the watershed public, the Clean Lakes Program Regulations require the state or tribal recipient of Clean Lakes funds to provide for, encourage, and assist the widest possible public participation in all Clean Lakes projects. Also to promote the formation of partnerships, the Clean Lakes Program Regulations require non-federal, cost-sharing funds for all projects. These cost-share funds may come in the form of direct dollars, state staff time, or by tapping a pool of local experts, machinery and volunteers. This buy-in of state and local partners promotes a sense of ownership in the project, which is necessary for long-term success. A few examples of successful projects are:

- The Lake Warramaug project in Connecticut demonstrates the importance of a strong local-state-federal partnership. In 1975, the citizens of three towns in the Lake Warramaug watershed banded together to form the Lake Warramaug Task Force to restore the declining lake. The citizen-run task force serves as a nonprofit organization to educate the public, raise funds, stimulate research, and mobilize the restoration efforts for the lake. Integrating these restoration efforts required the formation of partnerships between the citizens of the Lake Warramaug watershed, the regional planning agency, the tri-town commission, limnology experts, Connecticut environmental and agricultural agencies, state and local legislators, universities, foundations, the EPA Clean Lakes Program, the US Department of Agriculture's (USDA) Soil Conservation Service, and the Canada Ministry for the Environment. In essence, the strong local commitment of the task force was both the force that brought it all together and the glue that bound the effort to save Lake Warramaug.
- The Maskenthine Lake Project in rural Nebraska is using a variety of tools and programs to identify problems and build consensus on the actions to be taken to correct problems. The EPA Total Maximum Daily Load SWAT Team and funds from a mini-grant are being used to determine the assimilative capacity of the lake for atrazine, nutrients, and sediment. These data will serve as the basis for refining the watershed management plan. The state is using Nonpoint Source Program funds to develop and implement an information/ education program in the watershed, while Clean Lakes Program funds are being used to stabilize eroding shorelines and to construct a wetland area above the lake to decrease pollutant loading. The USDA has designated the Maskenthine Lakes watershed a Conservation Priority Area, which could take some highly erodible land out of row crop production, thereby decreasing the pesticide, sediment, and nutrient loading to the lake.

- The Lake Bemidji project in Minnesota illustrates the importance of an integrated holistic approach to watershed protection. The Clean Lakes Diagnostic/ Feasibility study of the lake and its watershed identified a close interrelationship between ground water and surface waters in the Bemidji area. The study concluded that degradation of either surface waters or ground water will likely affect the other. Having identified the sources and critical areas, the implementation plan for the Lake Bemidji watershed calls for a variety of educational activities as well as specific best management practices for urban, agricultural, and forestry sites that are designed to reduce nonpoint source pollution in lakes, streams, and aquifers within the project area.
- The EPA Region IV (Atlanta, GA) Clean Lakes Program has integrated four lake projects in the Appalachicola, Chattahoochee and Flint River Basins located in Georgia, Alabama and Florida in a comprehensive watershed project. These lakes—Lake Lanier, West Point Lake, Lake Walter F. George, and Lake Blackshear—include approximately 175 miles of impounded rivers that have been converted to reservoir habitat. Numerous nonpoint sources of pollution, as well as some point sources, are being addressed as part of this effort under the Clean Lakes and other programs.

Hundreds of communities across the Nation (in 49 states, Puerto Rico, and 18 Native American tribes) have used the structure of the Clean Lakes Program to assist them in implementing a watershed approach to lake protection. For years they have tried the holistic, integrated Watershed Protection Approach to protecting aquatic resources advocated by EPA—and it's true—it works.

California's Feather River Story: Building a Collaborative Process

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A cooperative erosion control program was initiated in 1985 for the East Branch North Fork Feather River watershed in California's northern Sierra Nevada. Pacific Gas & Electric Company (PG&E), along with 14 other public and private sector cosponsors, joined forces to develop a Coordinated Resource Management Program (CRM) that has contributed several million dollars to support the planning and implementation of a watershed restoration program. Poor land management practices in the past, including overgrazing, timber harvesting, road building, and mining, have resulted in the removal of upland and riparian vegetation, leaving barren streambanks vulnerable to erosional processes. Subsequent changes in water discharge and increases in sediment transport have impacted fish, wildlife, recreation values, and power production throughout the watershed, and have further eroded the economy of the local county.

The main objective of this program is to identify and demonstrate a process that integrates the contributions of all involved parties to provide solutions that are environmentally and economically acceptable. Secondly, initiation of the program also provides an opportunity to develop and test new techniques for reducing erosion, that are cost-effective and environmentally benificial.

The overall success of the erosion control program can be attributed to the implementation of the CRM process, where planning and decision-making are consummated through a consensus process. The CRM process is often used to solve complex resource management issues that involve multiple landowners and special interest groups extending over large geographic areas. This approach integrates the needs of participants into an action plan, where conflict is minimized and results are emphasized. Contributions of participants are leveraged to provide benefits at an affordable cost. Since the CRM process is already widely used by public land management agencies, it has increased the credibility and visibility of the project, which has provided more funding opportunities. A key element in the success of this process is that it must be locally driven to work properly, and all major stakeholders should be included to promote acceptance and trust.

The Feather River CRM project has generated an outstanding list of accomplishments since 1985. Of the 763,000 acres of the watershed, most have been inventoried for water quality problems; 246,000 acres have been inventoried to design-level intensity; 10 miles of the 770 severely degraded stream miles in the 2,398 stream mile watershed have been restored; and 3,000 acres of the 152,000 degraded acres of wetlands, meadows, and rangelands have been restored.

In addition, waterfowl populations have increased by 670 percent and fish populations have increased by 200 percent on monitored projects; 50 new jobs have been created; 64 landowners and 30 agencies and organizations have cooperated on projects and studies totaling almost $3 million in 4 years; the first stream meander reconstruction project in California was

completed in 1990; and a local junior college initiated the first Watershed Management Associate Degree program in California in 1990.

The Feather River story is an example of how collaboration, communication, compromise, and commitment can be used at the grassroots level to successfully implement natural resource enhancement programs, and boost the economy of a small rural county. Obtaining social change in the context of natural resource management is a complex process, and in many instances achieving social change is as difficult, or more so, than making changes in the ecosystem. The result, in this case, has produced practical and effective improvements on the land and desirable social changes among resource owners, managers, and users.

The CRM process is very worthy of careful consideration during the resource management planning process to facilitate cooperation and coordination at the local level, and to produce tangible results on the ground. Collaborative efforts such as this have demonstrated that long-term economic success can not be achieved at the expense of environmental values, and that public and private sector partnerships will facilitate programs to protect and enhance environmental resources. Responsible environmental management makes good economic sense.

Million Points of Blight©

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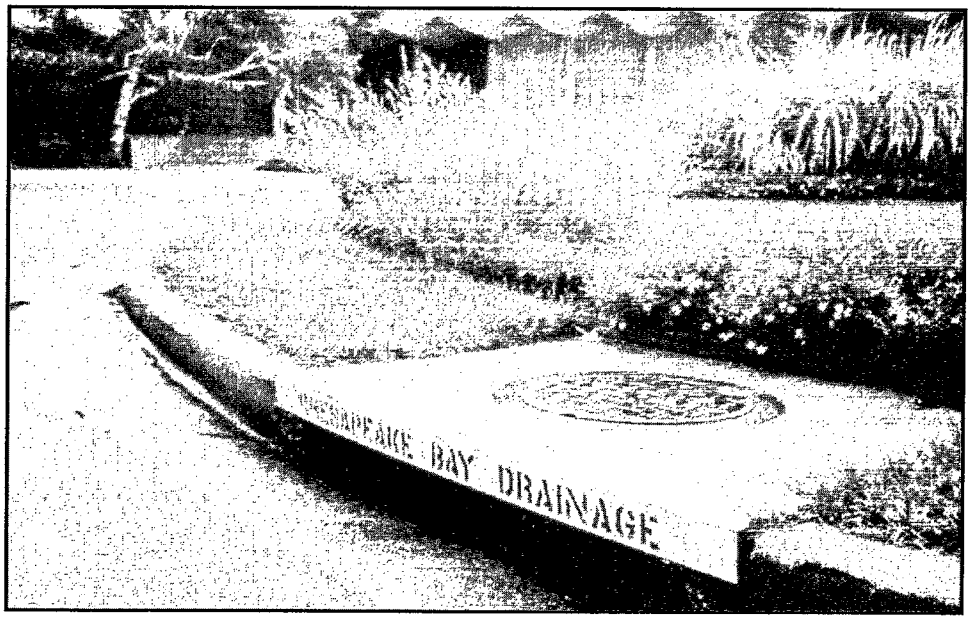
Nonpoint source pollution, or "pointless" pollution, originates from many different places. Some of this pollution is created when rain washes pollutants, such as cigarette butts, street litter, pet wastes, oil and grease, and excess fertilizers and pesticides, down storm drains. Other types of nonpoint source pollution are caused by various land-use practices, including farming, timber harvesting, mining, and construction. The U.S. Environmental Protection Agency (EPA) has determined that nonpoint source pollution is a leading cause of our nation's water quality problems.

In November 1990, the EPA issued a final rule to implement section 402(p) of the Clean Water Act, federal legislation aimed at preserving the quality of America's waters. This final rule requires cities with populations greater than 100,000 that have separate storm sewer systems to obtain a National Pollutant Discharge Elimination System (NPDES) permit. A main component of this storm water law is to educate the public about storm water runoff and nonpoint source pollution and what they can do to help reduce it. For this reason, many cities have become interested in storm drain stenciling to help them comply with these regulations.

The Center for Marine Conservation's national *Million Points of Blight*© storm drain stenciling campaign, funded in part by EPA, alerts people to a problem that they can correct through responsible behavior. Many people don't realize that their local storm drains are direct links to nearby streams and rivers, and ultimately, the ocean. The goal of *Million Points of Blight*© is to educate the public, both in coastal and inland states, about this direct connection between storm drains and local waterways. With help from volunteers, one million storm drains across the country will be stenciled with clean water messages such as "Don't Dump, Drains to Waterway" to help make that connection.

Million Points of Blight© serves as a national network for established stenciling programs run by state and local government, as well as several nongovernmental groups. Storm drain stenciling is not a new idea; in fact, some organizations have been conduct-



ing such projects for years, but the Center believed that it would be helpful for these groups to become a part of a network so that they could share ideas and success stories. There are currently 50 ongoing stenciling projects that are members of the *Million Points of Blight*© network. *Million Points of Blight*© also serves as a guide for individuals and groups which do not have storm drain stenciling programs in their areas. The Center provides educational materials on nonpoint source pollution and stencils to those who want to get stenciling started in their communities.

Baltimore County Waterway Improvement Program

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The extensive waterway resources of Baltimore County provide an array of valuable benefits to county citizens. With changes in land use and increased use of waterways, watersheds have become degraded to a point where many attributes such as good water quality, abundant recreational opportunities, variety of wildlife habitat, and economic benefits are no longer available to citizens. Recognizing the vital role waterways play in making Baltimore County a desirable place to live, work, and play, a major commitment has been made to reclaim its over 1,000 miles of rivers and streams and 175 miles of Chesapeake Bay shoreline.

The Department of Environmental Protection and Resource Management has developed an innovative program to address long-term, ongoing watershed degradation through a comprehensive Waterway Improvement Program (WIP). Program implementation involves the technical input of planners, engineers, and environmental scientists. The program strategy is to implement environmental restoration projects in six program components. These six Waterway Improvement Program components are:

- Shoreline protection and enhancement.
- Waterway cleanup.
- Waterway dredging.
- Storm water retrofitting.
- Watershed and stream restoration.
- Urban forestry.

While the regulatory programs adopted by Baltimore County eliminate or reduce the negative impacts of *new* or redevelopment, the WIP restoration strategies address many of the environmental problems in the older, *existing* communities.

Through the WIP restoration strategies, education awareness opportunities are also addressed. Individual citizens, volunteers, and community groups are contacted to increase the general understanding of the natural systems, human impacts, and possible choices for action. Through cooperation with Maryland Save Our Streams, education objectives are accomplished.

This innovative restoration effort, currently funded by a 6-year capital improvement budget of over $14 million (FY 1993-1998), involves coordination and administration of design, construction, and monitoring of each project. Due to the comprehensive nature of the program, projects are targeted to priority watersheds.

The implementation of the Waterway Improvement Program represents the county's commitment to restoring, enhancing, and protecting its water resources and all the associated benefits, especially for existing communities. This innovative program helps fulfill Baltimore County's responsibility to comply with recent federal and state environmental protection mandates.

Summary of Trinidad Lake North Land Treatment Watershed Project in South Central Colorado

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The Trinidad Lake North Land Treatment Watershed Project near Trinidad, CO, was inaugurated March 12, 1992. Six project sponsors signed a watershed agreement with the U.S. Department of Agriculture's Soil Conservation Service (SCS). The agreement and plan call for reducing sediment reaching Trinidad Lake from 166 to 62 acre-feet per year or 204,000 tons per year.

The watershed project area contains 111,000 acres of drainage area and is characterized by steep slopes, eroding streambanks, and poor range conditions. The watershed area is 93 percent privately owned, composed of 114 ranches averaging 542 acres in size. Below-average income characterizes the watershed area. Alternative agricultural enterprises are very limited due to soil types and precipitation.

Cost of this watershed project is $1,528,400, including $1,168,900 P.L. 566 funds and $359,500 local funds. During the last few months of fiscal year (FY) 1992, nine contracts, totaling $166,000, were signed with producers. An additional $400,000 is budgeted for FY 1993 for cost-sharing with 35 producers. The balance of the funding will be obligated in FY 1994 and FY 1995. Contracts may take as long as 10 years to complete.

The off-site annual economic benefit of the project is estimated to be $133,700. The on-site annual economic benefits will be $77,700.

The primary practices to control soil erosion within the watershed and reduce sediment to Trinidad Lake are:

Enduring Practices	Management Practices
Sediment Basins	Deferred Grazing
Critical Area Treatment	Cross Fencing
Pasture and Hayland Plantings	
Grade Stabilization Structures	
Tree and Shrub Planting	

The cost-sharing rate for enduring practices is 65 percent of the average cost of installing the practices. Cost-sharing for deferred grazing is limited to a one-time incentive payment of $1-$2 per acre (not to exceed $8,000).

During the first 3 years of the project, the educational component of the "Technical Assistance" will be implemented. Workshops are the chosen method of implementation. These workshops will present resource management concepts, method, and technologies.

Contractees will be strongly encouraged to participate in a workshop as a prerequisite for receiving P.L. 566 cost-share funds for deferred grazing. SCS will certify landowner or entity participation.

Project benefits other than reduction of sediment to Trinidad Lake include:

- Fisheries in Trinidad Lake will improve.
- Riparian habitat improvement will reduce erosion and improve wildlife benefits.
- Livestock-carrying capacity of the watershed is expected to increase by 20 percent.
- Recreational values of the area will increase.

The Watershed Management Game

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The Watershed Management Game was designed to help people understand how to protect water quality by managing the entire watershed holistically. The game simulates a wide variety of the activities performed and decisions made by those involved in watershed management (from government employees to private landowners). Originally developed as a training tool for water quality and land management agencies, the game has evolved into a product also suitable for local governments and anyone else interested in effective watershed management. The basic principles of watershed restoration and rehabilitation, including pollution control and prevention technologies, economic evaluation, and the decision-making process are demonstrated as play progresses.

The game board depicts a river running from its headwaters to a coastal estuary. The river passes through 11 major land resource areas or ecoregions, each with a different land use. Players float down the river and along the way choose game cards that direct the player to either use the land to produce consumer goods and services, and consequently make a profit, or to control pollution and rehabilitate the watershed—actions that cost money. Players compare the environmental damage caused by or improvement gained from each option selected. This allows players to attempt to balance personal profits with environmental protection and to see the consequences of their actions immediately—evidenced as changes in water quality, biologic integrity, or riparian condition.

The game was field tested and revised four times over the past 2 years. Table 1 outlines these tests. The same critique form and methodology were used for each trial, making it possible to determine whether problems with earlier versions had been corrected.

The game, which requires about one and one-half hours to complete, may be played as a facilitated group training, as a friendly competition between teams, or in a classroom setting. Two additional versions are being produced—a simplified one for high school environment and ecology classes and a complex edition that more closely simulates the total maximum daily load calculation and implementation process. The general version of the game, now in the final production process, should be available by June 1993.

Table 1. Field tests

Test Date	Location	Audience
Sept. 1990	Mustang Island, TX	State and federal Nonpoint Source Program employees
April 1991	Waggoner, OK	State and federal water quality monitoring staff
June 1992	Santa Fe, NM	USFS hydrologists and regional foresters
Sept. 1992	Waco, TX	Brazos River Authority and local government officials and employees

Lessons Learned from the Rural Clean Water Program with Selected Case Studies of Local Nonpoint Source Control Projects

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The Rural Clean Water Program (RCWP) was a 10-year experimental program to evaluate procedures for control of agricultural nonpoint source water pollution through voluntary participation. Begun in 1980, the RCWP selected 21 project sites across the Nation to achieve nonpoint source pollution control under widely varying conditions of terrain, climate, and water quality problems. Each local project faced unique problems in attaining desired water quality improvements. Some were more successful than others in obtaining producer participation and interagency cooperation and in documenting water quality improvements.

An evaluation of the RCWP, by the National Water Quality Evaluation Project at North Carolina State University, has identified national program and local project elements and strategies which increase the chances for successful projects in nonpoint source pollution reduction. The national-level program benefited from a number of factors, including:

- Participation and dedication of all federal agencies concerned with nonpoint source control.
- Up-front commitment of the total program funding.
- Strong commitment and financial support for water quality monitoring to provide evidence of water quality improvements.
- A thorough evaluation process of the program and its component projects to ensure feedback to participators and to record valuable lessons learned.

Important factors in local project success included:

- A high level of producer participation.
- A high and consistent level of project funding.
- A clear definition of the water quality problem.
- Identification of critical source areas and target pollutants contributing to the waterbody pollution.
- Targeting best management practice (BMP) implementation to the identified critical areas.
- Well-designed water quality monitoring programs.
- Strong agency support at the national, state, and local levels.

Other factors such as state regulations and landowner perception of the pollution problem also played important roles.

Several effective local projects dealt constructively and resourcefully with the complex elements of their situation. The Oregon project utilized social ties and financial disincentives at the local dairy cooperative to implement BMPs that reduced bacterial concentrations in shellfishing waters. Concentrated BMP implementation in a small area of intense animal operations and a simple but very

effective monitoring program yielded striking declines in bacterial and phosphorus concentrations in the Snake Creek, Utah, project. A large-scale and well-funded program, combining voluntary and regulatory incentives to implement BMPs, documented significant declines in nutrient levels in water entering Lake Okeechobee, Florida. Vermont's project utilized advanced monitoring protocols and tracking of BMP implementation with a geographic information system to document reduced bacterial levels, which allowed swimming beaches in St. Albans Bay to be reopened.

Forests and Water Quality

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Forested lands, particularly streamside forests, significantly influence water and the associated living resources. Permanently forested watersheds with natural stream channels have low peak flows, low sediment loads, and sustain abundant aquatic life. Forests reduce total runoff through interception and transpiration. The forest floor absorbs precipitation and prevents overland flow, thereby preventing erosion. Reforestation can be part of the solution to watershed problems. Agricultural research has documented the effectiveness of riparian forest buffers in reducing nonpoint source pollution in agricultural watersheds. Recent work has documented the effectiveness of streamside trees in reducing nitrate levels in ground water.

Riparian forests significantly contribute to the biological integrity of streams. The aquatic life in small feeder streams is dependent on near-stream vegetation for food, temperature, and stream stability. Trees contribute woody debris to streams to provide important habitat for aquatic life. Trees are also critical for the stability of headwater streams.

Proper forest management and timber harvesting are compatible with maintaining watershed values. There is a long history of forestry on municipal watersheds. Research on forested watersheds has repeatedly demonstrated the effectiveness of best management practices (BMPs) in controlling adverse effects. State foresters have been promoting BMPs for 20 years. A compliance survey conducted over the last 10 years has documented good use of the voluntary BMPs.

Storm Water Best Management Practices for the Ultra-Urban Environment

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Summary

Various federal and state environmental programs require the use of on-site structural best management practices (BMPs) to control the quality of storm water discharges from development sites. Space constraints, extremely high property values, soil conditions, high water tables, and the proximity of other building foundations often preclude the use of extended dry detention, wet ponds, or infiltration systems for infill construction or redevelopment in the intensely built-up centers of major cities, where pollutant loads are usually the greatest. Unconventional solutions with equivalent or better pollution removal efficiencies must be applied in these "ultra-urban" environments.

Alexandria, VA, has adopted and published design criteria for a number of nonconventional BMPs, many of which employ intermittent sand filter technology. Some of these ultra-urban BMPs were developed by pioneering jurisdictions throughout the United States; other BMPs were devised by the city's engineering staff. Alexandria's *Watershed '93* Resource Fair display included cutaway graphic illustrations and color photographs of "ultra-urban" BMPs constructed in the city or in the originating jurisdictions. A coordinated tape-slide presentation illustrated the concept of "ultra-urban" BMPs and demonstrated their features through construction progress color slides. The following BMPs are highlighted:

- Storm water surface sand filter basins, in widespread use in Austin, TX, are readily adaptable for large development projects.
- Underground vault storm water sand filters employed in the District of Columbia allow full economic use of surface areas in densely built-up locations.
- Double-trench shallow storm water sand filter systems adopted by the State of Delaware can be placed either in or adjacent to paved areas.
- Simple trench and modular storm water sand filters developed by Alexandria are suitable for small or medium-sized sites.
- A peat-sand storm water filter, adapted from a Washington Council of Governments design, allows ultra-urban applications where high pollutant removal is required.
- Water quality volume detention tank BMPs, devised by Alexandria for use in combined sewer areas, capture the most polluted storm water for treatment in the wastewater treatment plant.

Copies of both the *Northern Virginia BMP Handbook* published by the Northern Virginia Planning District commission and the *Alexandria Supplement to the Northern Virginia BMP Handbook* were available for viewing at the display, with order blanks provided to interested parties.

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California's Rangeland Watershed Program Poster Summary

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Half of California's 40 million acres of rangeland is privately owned. Most surface water in California flows through privately owned rangeland that is located between forested areas and major river systems. Soil erosion (sheet, rill and streambank) and sedimentation are the main contributors to water quality impairment on rangeland.

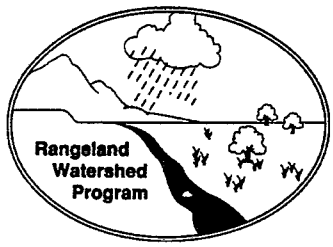
Achieving society's environmental quality objectives can be successful only if landowners participate in the process. To help landowners understand and participate in water quality problem identification and solutions, the University of California Cooperative Extension Service and the U.S. Department of Agriculture's Soil Conservation Service (SCS) have initiated a joint program of education and technical assistance focusing on private rangeland owners. This program addresses issues identified by the Range Management Advisory Committee to California's Board of Forestry as well as state and federal legislation.

Program Objectives

- Develop public understanding of watershed management.
- Inform rangeland owners and managers of how water quality legislation affects private rangeland management.
- Facilitate development and implementation of a Rangeland Water Quality Management Plan in California.

Activities

This project is conducting internal training for Farm Advisors and SCS Conservationists. Education programs for ranchers are conducted including Ranch Planning and Grazing Management Short Courses. The project organizes and publishes Fact Sheets for use in staff and landowner education programs. We also provide technical support for watershed monitoring program design, coordinated resource management planning, and technical review of management measures.



Involvement of Citizen Volunteers in Watershed Management in the Chesapeake Bay Basin

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Volunteers have made significant contributions to the water quality data base in the Chesapeake Bay Basin. The Chesapeake Bay Citizen Monitoring Program has been collecting water quality data since 1985 and now has about 160 people monitoring some 135 sites in 3 states. Two new projects began in 1991—riparian buffer zone management and monitoring and collection of rain samples for an atmospheric deposition study.

The use of volunteers in environmental monitoring has been increasing rapidly over the last 5-7 years nationally. This involvement of citizens directly in watershed management has important benefits:

1. Data and information needs far outstrip the resources available to managers for this purpose and citizens can fill the gap.
2. Citizens become aware of and gain an understanding of the ecological processes going on in their watershed. The watershed then has a solid constituency committed to raising and spending the money necessary to restore and protect it.
3. An overall watershed management program that involves citizens (including students), businesses, industries and scientific institutions as well as government personnel can develop true partnerships and working relationships among the groups so that implementing restoration and protection programs will progress.
4. When enough citizens become true stewards of the land, air, and water, desired goals for preservation of a watershed—be it a stream, lake, river, or bay—will be reached.

We have demonstrated that volunteers can contribute credible scientific data to the understanding of the Chesapeake Bay ecosystem. These data can be used to define the baseline, to detect trends, to screen for particular pollutants, to identify gross visual problems, and to augment data being collected by professionals.

The Alliance has provided staff support to organize several broad-based, grass-roots watershed protection organizations that work to protect and promote the scenic, recreational, historic, economic, and ecological values of a river. These groups actively protect the beauty; preserve water quality; educate both citizens and public officials of opportunities to help; become involved in local planning and development issues and decisions affecting the watershed; provide volunteers for citizen monitoring projects; and sponsor field and canoe trips on the river.

Advance Identification

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Advance Identification (ADID) of disposal areas is an advance planning process under which the U.S. Environmental Protection Agency (EPA), in cooperation with the Corps of Engineers, may identify wetlands and other waters which are either generally suitable or unsuitable for the discharge of dredged and fill material prior to the receipt of a section 404 permit application. The ADID process generally involves collection and distribution of information on the values and functions of wetland areas. The information provides the local community with information on the values of areas that may be affected by community activities as well as a preliminary indication of factors which are likely to be considered during review of a section 404 permit application. The ADID process is intended to add predictability to the wetlands permitting process and better account for losses from multiple projects within a watershed. The process also serves to inform the local population of the values and functions of wetlands in their area and generates environmental information valuable for other purposes. Because they are usually based on watershed planning, ADID efforts are extremely compatible with geographic and ecosystem initiatives such as EPA's Watershed Protection Approach.

While an ADID study generally classifies wetland areas as suitable or unsuitable for the discharge of dredged or fill material, the classification does not constitute either a permit approval or denial and should be used only as a guide in the planning of future activities. The nature of the classification is strictly advisory.

As of December 1992, there were 35 completed ADID projects and 36 ongoing ADID projects ranging in size from less than 100 acres to greater than 4,000 square miles. Although ADID projects can be resource intensive activities, some have been completed in as short as 6 months. EPA experience indicates that the more local the ADID project boundaries, the more complete and effective the ADID analysis and results. EPA has seen an increase in cost-sharing and expects more states and localities to provide funds to support ADID or other comprehensive planning efforts.

Experience shows that local cooperation and support are vital to the success of the ADID project. Recently, ADIDs have been initiated by local entities in order to facilitate local planning efforts. These efforts have proven to be the most successful way for generating support for wetlands protection. Cooperative ADID efforts may provide additional information useful to the planning process. In the West Eugene Wetlands Special Area Study (Oregon), local ADID efforts did lead to a section 404 general permit. Because the ADID was incorporated into the City of Eugene's general comprehensive plan, and due to the fact that Oregon land use policies have the effect of local land use law, the ADID effort streamlined the regulatory process.

Watershed Screening and Targeting Tool

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Targeting watersheds to receive increasingly scarce water management resources is an important step toward improving water quality. Water resource managers need tools to help them assess, compare, prioritize, and target the water quality problems of watersheds within their jurisdictions more easily. Responding to this need, the U.S. Environmental Protection Agency (EPA) Region IV and Office of Wetlands, Oceans and Watersheds have worked cooperatively to develop the Watershed Screening and Targeting Tool (WSTT). The prototype of the WSTT has been developed to access data from Alabama and Georgia.

WSTT, an innovative method for screening and targeting watersheds, combines compiled EPA mainframe data, ranking procedures, and a screening model with a PC-based, user-friendly interface. A schematic of the components of WSTT is shown in Figure 1. Built-in maps allow users to easily select watersheds, or sub-watersheds, to screen and compare. They may examine particular data bases; sort on selected parameters; or create graphs and reports for selected watersheds on land use, water quality, water supplies, impoundments, and point source facilities. A sample screen is shown in Figure 2.

WSTT can be used to identify, rank, and target areas of particular concern. Two targeting techniques are provided. The first uses multiple criteria to conduct a preliminary screening, where each criterion is compared with a default or user-defined reference value. The second permits a more detailed comparative analysis of selected watersheds. Several objectives can be defined and, within each objective, up to seven weighted criteria specified. Criteria can be selected by the user from WSTT data bases or defined by the user. WSTT data bases include information on water resources, water quality, point sources, land use distributions, and agricultural practices.

WSTT also includes a Watershed Screening Model (WSM) that permits simple watershed assessments to predict daily runoff, streamflow, erosion, sediment load, and nutrient washoff. Users can identify seasonal and year-to-year variability of runoff and its associated pollutants. Both point and nonpoint source

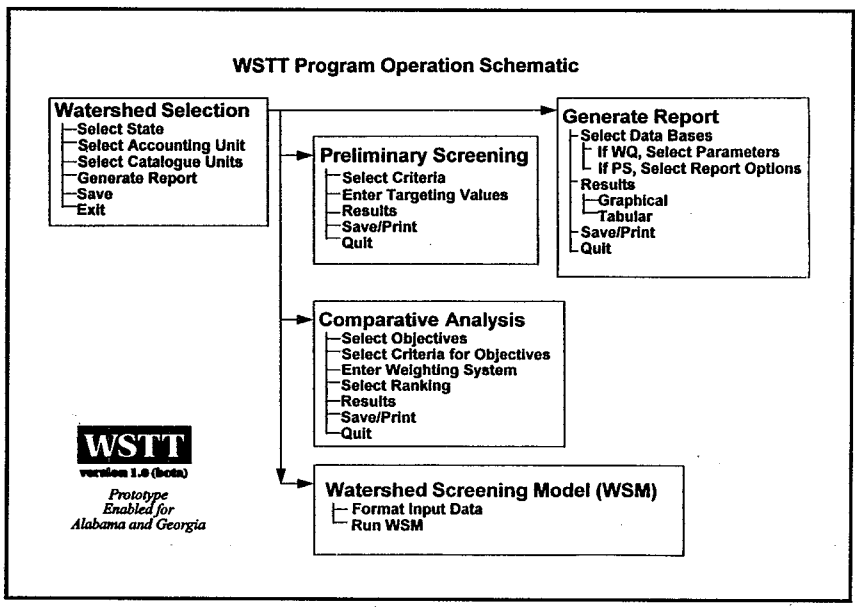

Figure 1. WSTT program operation schematic.

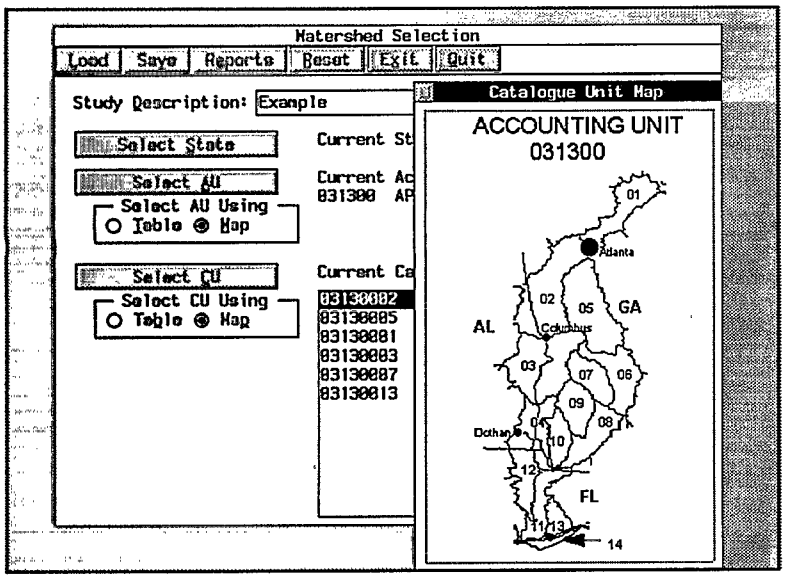

Figure 2. Sample WSTT screen.

contributions are estimated under high-, average-, and low-flow conditions. WSTT data bases are used to create default input data files for applying WSM. Users can review, update, or replace the default data as appropriate. WSM uses a daily timestep and local precipitation and temperature data. Either graphics or tables can be used to present the results of the WSM application.

Environmental Protection Agency Mainframe for Water Quality Analysis and Watershed Assessments

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National water quality data files and systems available on the U.S. Environmental Protection Agency (EPA) mainframe provide direct access for water quality analyses and watershed assessments. This study is a mosaic of data and tools that have been applied to a study area near Morgantown, WV, within the Upper Monongahela watershed (Figure 1). The data and tools presented here, along with others available on the EPA mainframe, can be applied to the 2,150 watersheds on the mainframe to assist in assessing water quality conditions and trends across the continental United States.

In this example application, the Upper Monongahela watershed, more than 160 ambient monitoring stations and 120 National Pollutant Discharge Elimination System facilities were found in the watershed using STORET, the Permit Compliance System (PCS), and the Industrial Facilities Discharge data base (IFD). Stations within the watershed were found to belong to the monitoring programs of West Virginia, Pennsylvania, the U.S. Army Corp of Engineers, and EPA. The data collected at these stations are easily accessible. Data on hydrology, streets and roads, monitoring sites, discharge locations, and water supplies are all available on the mainframe and can be displayed graphically (Figure 2).

The Upper Monongahela watershed is located in northern West Virginia. This region is generally characterized by low rolling hills with little flat land. Average

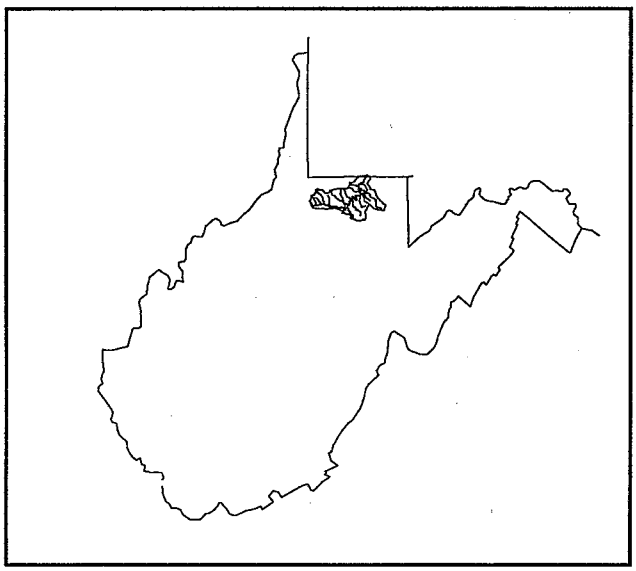

Figure 1. Upper Monongahela watershed.

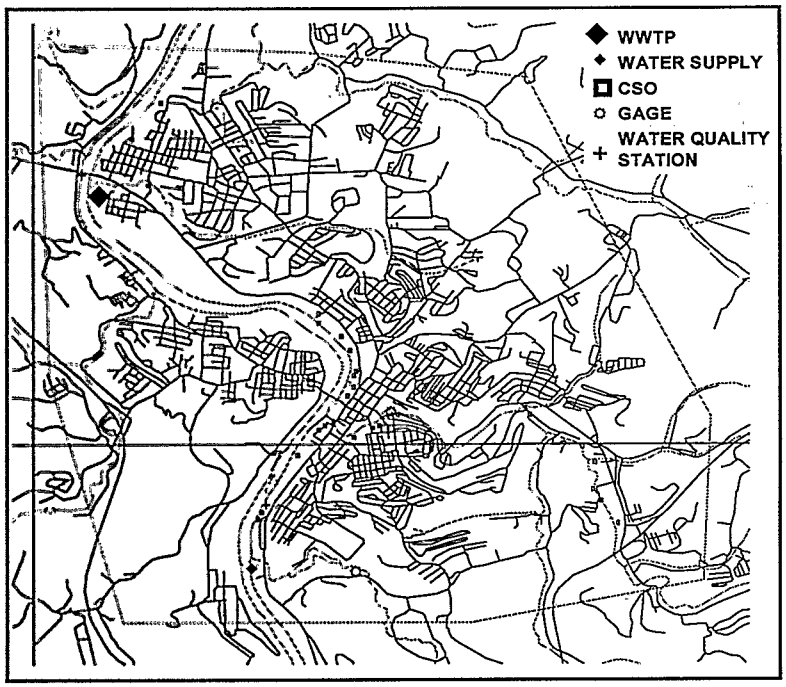

Figure 2. MDDM plot of the study area.

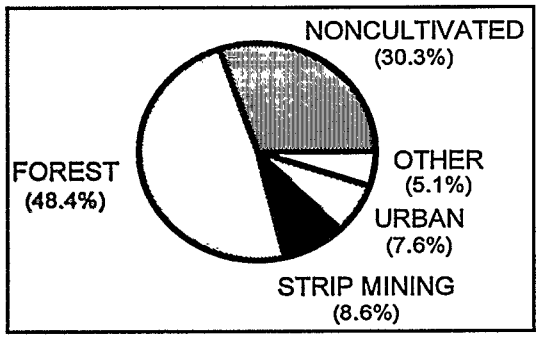

Figure 3. NRI land use summary.

rainfall in the area is between 40 and 44 inches per year. As the hydrologic data on the mainframe illustrates, the Monongahela River is formed by the confluence of the West Fork and Tygart Valley Rivers. This confluence occurs just upstream of the watershed. The drainage area for the watershed is approximately 460 square miles. The EPA Reach File provides indexes and graphics for 603 steam segments, 636 stream miles, and 20 shoreline miles for 73 lake segments in the Upper Monongahela watershed. Design flows can be determined using data from the Gage file. The long-term mean flow, the harmonic mean flow, and the 7-day, 10-year low flow in the Monongahela River at the mouth of the watershed were determined to be 4,553, 1,416, and 296 cubic feet per second, respectively. The 7-day, 10-year low flow ranges from 0.00 to 0.14 $(ft^3/s)/mi^2$ across the basin.

A problem of major concern in the area is the chemical quality of surface water. Many streams are acidic and highly mineralized because of drainage from coal-mining areas (USGS, 1985). The 1987 National Resource Inventory classifies over eight percent of the watershed as being involved in strip mining (Figure 3). Another eight percent is composed of various urban land uses. The largest classification of land use within the watershed is forest, at almost 50 percent. Water quality data retrieved from STORET indicated an increase in phosphorous and solids loadings between a station upstream of the urbanized study area and a station downstream. Examination of the data from the station below a large wastewater treatment plant in the area showed a decreasing trend in fecal coliforms.

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Watershed Management in Tampa Bay: A Resource-Based Approach

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The Tampa Bay National Estuary Program (TBNEP) is a partnership of local, regional, state, and federal governments charged with drafting a comprehensive conservation and management plan (CCMP) for the restoration and protection of living resources in Tampa Bay. While water quality measurements traditionally have served as the surrogate of a waterbody's viability, the TBNEP resource management strategy emphasizes a critical *next step* by linking water quality to the environmental requirements of Tampa Bay's most important habitats. Seagrasses are used to demonstrate the steps involved in this process, which starts with identification of the impacted living resource and proceeds through implementation of specific management actions.

- *Set Bay restoration targets.* The *pre-impact* areal distribution of seagrass is subtracted from present day distribution to identify areas for potential restoration.
- *Determine optimal loading rates.* To attain seagrass light requirements, chlorophyll concentration resulting in 35 percent incident light at depth (2 m) is used to estimate, using regression analyses, *optimal* nutrient loading rates.
- *Allocate reduction for pollutants.* Goals for reductions in nutrient loadings for each bay segment are calculated by subtracting the optimal loading rates from existing rates. Through negotiations among local, state and federal agencies and industries, necessary reductions will be allocated, perhaps using a *bubble concept* approach, to watershed sources.
- *Implement inter-governmental agreement.* Tampa Bay National Estuary Program participants agree to:
  - Reductions in pollutants based on Bay Restoration targets.
  - Implement agreement through discharge permits and local government comprehensive plans.

Under this strategy, resource-based water quality requirements, and associated pollution load reduction goals, will be incorporated into mandated federal and state programs for point and nonpoint source pollution control. Pollution load reduction goals will also be incorporated into local government comprehensive plans.

One of the most challenging aspects of the TBNEP watershed management strategy will be the allocation of reductions in contaminants among major industries and local governments that are currently contributing pollutant loads to the bay. TBNEP is providing a forum in which consensus may be reached on an approach for allocating load reductions among the key players, many of whom are represented in the TBNEP Management Conference. Specific commitments, including timelines and identification of funding sources and monitoring requirements, will be developed and included in the overall plan for bay management.

Storm Water Pollution Prevention in the Santa Clara Valley, California

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An industrial source control program is a vital part of a well-designed watershed storm water pollution control program because industrial land uses have been shown to contribute substantially to the mass loading of several pollutants present in storm water runoff from urban areas (Woodward-Clyde Consultants, 1991). Municipalities which need to manage storm water pollutants in their watersheds because of recent U.S. Environmental Protection Agency (EPA) regulations (USEPA, 1990) can more effectively do so by including in their storm water management plans an active program of outreach and cooperation with industrial facilities that extends beyond passive reliance on broad-brush state and federal regulations on individual industrial facilities (USEPA, 1991; California State Water Resources Control Board, 1991).

A program targeted at industrial facilities not only assists the municipality's constituents in complying with complex and onerous storm water regulations, but also powerfully assists the municipality in achieving its charge of reducing pollutants in municipal storm water discharges by controlling storm water pollutants at the sources.

Industrial outreach and cooperation have been an integral part of the Santa Clara Valley Nonpoint Source Pollution Control Program. A key aspect of the Program's strategy is to demonstrate whether the source control approach, vigorously implemented, can succeed in reducing pollutants in storm drain discharges to the Lower South San Francisco Bay, avoiding more costly regionwide measures such as large-scale detention basins.

During the period when state and federal regulations were being developed, the Program hosted a series of workshops to describe emerging state and federal regulations. Later, the Program prepared detailed, step-by-step written materials to encourage compliance and assist industrial firms in complying efficiently and cost-effectively, including a "sample" compliance plan for a fictitious facility and manuals describing best management practices (BMPs) recommended as effective storm water pollution control methods for three industrial categories (Santa Clara Valley Nonpoint Source Pollution Control Program, 1991, 1992a, 1992b).

The BMPs and other materials were developed with extensive cooperation among local and regional environmental agencies and with the regulated community. This approach ensures the adopted BMPs can be practically implemented, are cost-effective, and are effective at controlling pollutants in storm water discharges. The materials encourage practices the Program finds most effective at controlling pollutants of concern in discharges to San Francisco Bay. The practices also reflect the preferences of participating Program municipalities, and the multiple overlapping local agencies whose authority includes aspects of storm water pollution control.

An effective municipal program supporting industrial storm water pollution control can drive an important contribution to the goal of reducing pollutants in municipal storm drains.

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discharges of storm water associated with industrial activities (Water Quality Order No. 91-13-DWQ).

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The Baltimore County "100 Points of Stream Monitoring": Building Partnerships and Public Support for Watershed Management Through a Volunteer Water Monitoring Project

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In 1989, Maryland Save Our Streams (SOS) and the Baltimore County Department of Environmental Protection and Resource Management (DEPRM) created the Citizens for Stream Restoration Campaign with the primary goal of building a citizen constituency for local waterways through ongoing education, leadership development, watershed protection, and restoration strategies.

A fundamental component of the Campaign is the "100 Points of Stream Monitoring," involving volunteers in a seasonal assessment of 100 sites along freshwater streams using the collection and identification of benthic macroinvertebrates as well as a physical habitat assessment.

Cohesive watershed management requires a variety of strategies including extensive monitoring. While recognizing the need, the county was unable to implement a biological monitoring program due to shrinking resources. Volunteer collection of critical data is cost-effective and assists the county in protecting and managing its watersheds. To date, over 700 volunteer monitors have been trained.

Volunteer monitoring techniques are based on Protocol 11 of the U.S. Environmental Protection Agency recommended methods outlined in *Rapid Bioassessment Protocols for Use in Streams and Rivers* (May 1989) intended for professional use. The 100 Points is among the first programs nationwide to train volunteers to this level of sophistication.

Personnel from county, state, and federal agencies serve on the Technical Advisory Committee (TAC), which oversees data coordination, management, and use. The 100 Points Steering Committee (composed of educators, community leaders, and local business people) works cooperatively with the TAC and SOS to guide all aspects of the project.

This experience demonstrates the feasibility of combining scientific credibility with community participation in water monitoring. By providing cost-effective, quality-assured, critical data, promoting community and government partnerships, fostering a stewardship ethic, and developing crucial citizen leadership, volunteer monitoring will reach its full potential.

Working Together to Reduce Irrigation-Induced Erosion, West Stanislaus Hydrologic Unit Area

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The West Stanislaus Hydrologic Unit Area (HUA) was funded in fiscal year 1991 to reduce nonpoint source (NPS) pollution loadings of organochlorine residues to the San Joaquin River caused by irrigation-induced erosion in western Stanislaus County, CA.

Numerous studies preceded the HUA funding. Coordination of ongoing efforts have elevated awareness of the problem among agency personnel and the local community. University of California Cooperative Extension (UCCE), the Soil Conservation Service (SCS), the West Stanislaus Resource Conservation District (RCD), and the Agricultural Stabilization and Conservation Service (ASCS) have each played an important role in coordinating an information and education program. This coordinated effort has led to a fairly successful delivery of technical assistance and the installation of on-farm conservation practices to reduce irrigation-induced erosion.

In addition to interagency HUA efforts, the SCS Water Resources staff recently completed the West Stanislaus Sediment Reduction Plan prepared in cooperation with the Regional Water Quality Control Board (RWQCB) and the RCD. The report emphasizes "the best solution is a local solution" and is the result of input from the local farmers, county and state agencies, and an SCS interdisciplinary team including an economist and sociologist. University of California Riverside researchers identified a polymer that has potential for reducing irrigation-induced erosion. Several field trials by UCCE staff demonstrated there were clear benefits from this polymer in sediment reduction, improved water quality, and increased water infiltration. Further evaluations will determine the most effective concentration, the number of applications per season and the effectiveness on various soil types.

A concerted, ongoing, and complementary effort among these agencies was aimed at heightening awareness and increasing voluntary adoption of on-farm conservation practices. Workshops have been conducted and educational materials (such as newsletters, fact sheets, and color charts depicting ranges of sediment concentrations) have been developed; tours and demonstrations of on-farm practices have been cosponsored.

The RCD developed a *Farmer to Farmer* video, and UCCE produced English and Spanish versions of a *Best Management Practices for Sediment Reduction* video. The RCD obtained a Clean Water Act section 319 Demonstration Project to evaluate best management practices, and the SCS contracted with the U.S. Navy to help meet NPSP objectives.

Monitoring efforts have been provided by RWQCB, the U.S. Environmental Protection Agency, California-EPA, U.S. Geological Survey, and the Department of Water Resources San Joaquin River Management Advisory Council. The Board of Directors of the Patterson Irrigation District set the example for other West Stanislaus districts by aligning itself with the objectives of the HUA.

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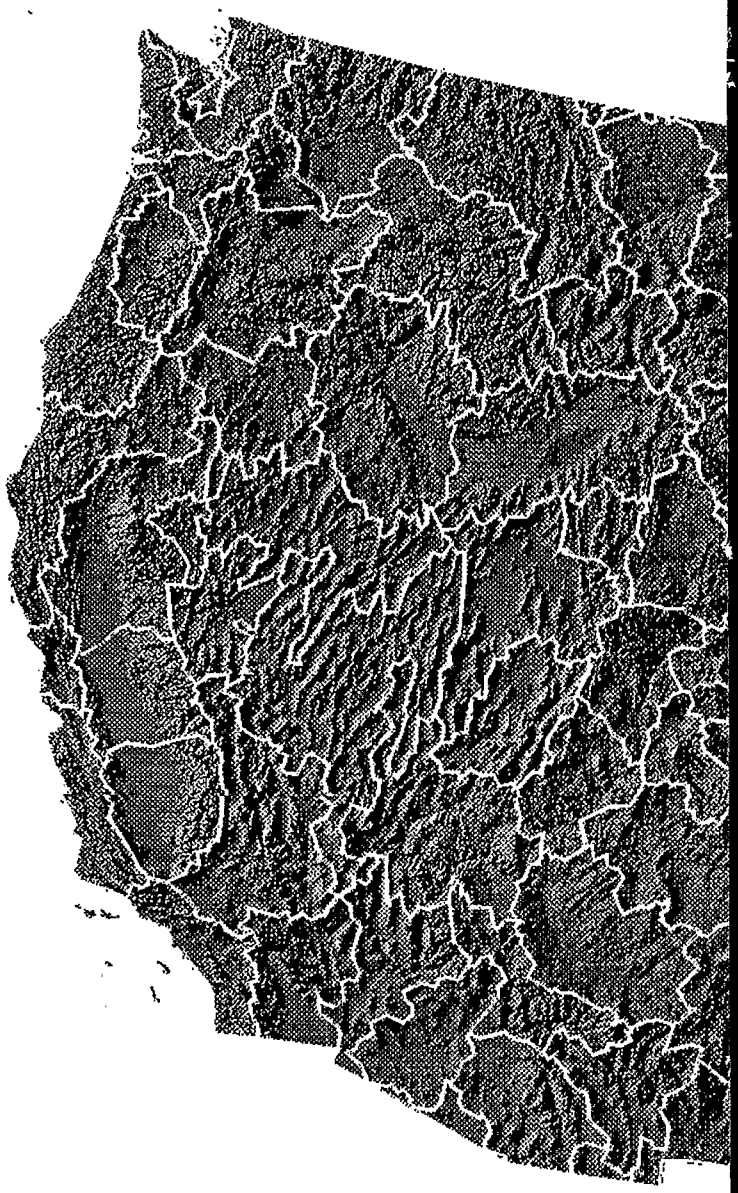
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