THE ENGINEER AND THE ENVIRONMENT

Papers presented at the Seminar on the Engineer and the Environment sponsored by the Department of Conferences and Institutes of the University of Minnesota in cooperation with the American Society of Civil Engineers, Northwestern Section, Water Resources Group on November 20, 1970 at the Nolte Center for Continuing Education.

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WATER RESOURCES RESEARCH CENTER
UNIVERSITY OF MINNESOTA
GRADUATE SCHOOL

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FOREWORD

This Bulletin is published in furtherance of the purpose of the Water Resources Research Act of 1964. The purpose of the Act is to stimulate, sponsor, provide for, and supplement present programs for the conduct of research, investigations, experiments, and the training of scientists in the field of water and resources which affect water. The Act is promoting a more adequate national program of water resources research by furnishing financial assistance to non-federal research.

The Act provides for establishment of Water Resources Research Institutes or Centers at Universities throughout the Nation. On September 1, 1964, a Water Resources Research Center was established in the Graduate School as an interdisciplinary component of the University of Minnesota. The Center has the responsibility for unifying and stimulating University water resources research through the administration of funds covered in the Act and made available by other sources; coordinating University research with water resources programs of local, State and Federal agencies and private organizations throughout the State; and assisting in training additional scientists for work in the field of water resources through research.

This Bulletin is number 38 in a series of publications designed to present information bearing on water resources in Minnesota and the results of some of the research sponsored by the Center. Current environmental issues, with particular emphasis on water resources problems, are discussed in connection with a Seminar on the Engineer and the Environment. In view of the great public concern and the urgent need for information on this topic, this Bulletin is being published as a public service. It is thus being made available to a wide variety of people concerned with the research, technical, educational and operational aspects of water resources.

INTRODUCTION

This bulletin contains the papers presented at the "Seminar on the Engineer and the Environment", presented by the Department of Conferences and Institutes of the General Extension Division of the University of Minnesota. The seminar was planned in cooperation with the Northwest Section of the American Society of Civil Engineers. The purpose of the seminar was to inform engineers of current environmental issues, with particular emphasis being placed on water resources problems. The planning for the conference was based on the premise that the engineering profession should be aware that environmental issues are of paramount concern to society and that the profession is responsible for giving full consideration to these issues in addition to fulfilling the traditional role of solving purely technical problems.

The program of the seminar is given below:

November 20, 1970

8:00 a.m.	Final Registration - Main Desk, Nolte Center
8:25	Welcome and Opening Remarks, Harry Dedering, Associate Director, Department of Conferences and Institutes, University of Minnesota, Minneapolis
8:30	Film - "People Eco-Action"
9:00	An Ecological Approach to Natural Resource Problems, Robert W. Burwell, Regional Director, Bureau of Sport Fisheries and Wildlife
9:45	Coffee Break
10:15	Environmental Aspects of Water Resources Planning and Development, Colonel Charles I. McGinnis, District Engineer, St. Paul District, U.S. Army Corps of Engineers
11:00	Drainage and the Environment - Panel Evan Allred, Professor of Agricultural Engineering, University of Minnesota Walter J. Ochs, Assistant State Conservationist, Soil Conservation Service, St. Paul Burton Round, Wetland Coordinator, Bureau of Sport Fisheries and Wildlife, Minneapolis
12:15 p.m.	Luncheon
1:15	The State Concern in Engineering Planning for Water Resources, Guy Kelnhofer, Director, Water Resources Planning and River Basin Coordinator, Minnesota State Planning Agency
2:00	Social Aspects of Ecology, Roland Comstock, Director, Environmental Affairs, Northern State Power Company, Minneapolis
2:45	Coffee Break
3:15	The Challenge of Environmental Concern in the Future of Engineering, Leon Weinberger, Consultant, Vice President, Enviro-Contro., Inc. Washington, D.C.

The following persons served on the Planning Committee for the seminar:

Richard W. Leonard, U.S. Army Corps of Engineers, St. Paul
J.R. Calton, U.S. Army Corps of Engineers, St. Paul
Harry Dedering, Associate Director, Department of Conferences and Institutes, University of Minnesota
Emanuel I. Jensen, P.E., Consulting Engineer, Minnetonka
Floyd J. Laumann, P.E., Hancock Concrete Products Company, Minneapolis
Edward Silberman, Professor of Civil Engineering and Director, St. Anthony Falls Hydraulic Laboratory, University of Minnesota
Carl Stephan, Bureau of Sport Fisheries and Wildlife, Fort Snelling, Minneapolis

The seminar chairman and moderator was Dr. Alvin G. Anderson, Professor of Civil Engineering, St. Anthony Falls Hydraulic Laboratory, University of Minnesota, Minneapolis.

The seminar papers are arranged in this Bulletin in the order in which they were presented.

AN ECOLOGICAL APPROACH TO NATURAL RESOURCE PROBLEMS

by R. W. Burwell, Regional Director,
Bureau of Sport Fisheries and Wildlife,
Minneapolis, Minnesota

A few years ago a plague struck a small isolated village in Bolivia. Before it could be identified--it turned out to be hemorrhagic fever--the plague killed almost all of the children in the village.

A study of events gave the answer. It seems that earlier in the year the village had been sprayed with DDT to eliminate certain insects. In the ensuing months there was a mysterious die-off of the house cats that had for years roamed throughout the village. It developed that following the extensive spraying, the cats in prowling through vegetation and back alleys got DDT on their fur--and, being cats, continued their habit of licking themselves clean. Following the die-off of cats, the village's normally modest population of mice erupted--mice were everywhere and the stain and odor of their urine was present in every village hut.

What proved to be the carrier of the virus of the hemorrhagic fever? It was carried in the urine of the mice, deposited where children slept, ate, and played.

A tragic chain of events, especially so when the first step started with the best of intentions.

This story is a simple lesson in ecology. It illustrates what the word means--the mutual relationships of the biotic in the environment. It warns us that processes are more than isolated cause and effect linkages. It demonstrates that the world about us is much more complicated than we once thought it to be. And it tells us that man cannot travel with impunity down a narrow road of single interest.

Most of us here today have a profession. We are lawyers, economists, biologists, educators, civil engineers, and so on. In the process of living and in the process of carrying out our jobs, we daily influence the environment in which we exist. For most of us there is a compelling motivation to alter our environment at some time and in some place. Individually, I spray my backyard for mosquitos, you plant a shelterbelt, she puts a combination weed-killer and fertilizer on her lawn, he clears the aquatic vegetation from the lake in front of his cabin.

Similarly, our organizations and agencies act to change the environment but on a larger scale. The Bureau of Reclamation constructs a reservoir to irrigate thousands of acres of land; the Soil Conservation Service installs measures to reduce runoff or channelize a stream course to hasten it; my Bureau creates an expansive marsh to produce ducks; the Corps of Engineers deepens a river channel to provide water transportation, and so on.

And in the last decade or so, the impact on ecological communities has been compounded by the collective action of Federal, State, and local agencies, as for example, the Missouri Basin Project and the upcoming Mississippi River 12-foot channel.

At this point, let me say that I do not maintain that these examples of our actions are bad: I simply note that these actions are going on.

There will be similar actions in the future as long as men see opportunities to develop and use natural resources. This being so, those of us who influence the use of natural resources have a responsibility to accept and develop what might be called ecological thinking. I do not mean just biologically, but in relation to all of the factors and variables of the complex problem of natural resource management.

As we all know, man's history of relationship with the environment is not a record which can be pointed to with general pride. We have made, and we continue to make, a lot of mistakes. Some of our mistakes are due to the inherent complexity of nature and some are due to our listening to the wrong voices. Technological mistakes can be avoided as the relevant sciences are improved and the techniques of application are developed. Other mistakes can be avoided as the voices of the public (as in the case of those who would exterminate the timber wolf) are evaluated in relation to the voice of science (as in the case of the wildlife biologist). But there is one class of mistakes which is, in my opinion, most difficult to avoid. These are the mistakes of a unitary approach which are difficult not to make because most of us are trained and accustomed to think in terms of disciplines, skills, and a concentration of effort.

This observation leads me to a familiar conclusion. Natural resource problems cannot be solved in the best way by a unitary attack on them. Natural resource problems are not just scientific problems (and certainly are not soluble by some single science) nor are they just engineering problems, or economic problems, or legal problems, or political problems, or--when we don't know what else to suggest--educational problems. Every natural resource problem has many facets and the usual specialist is equipped to deal only with one of them. It is not that we can dispense with the skills and the knowledge in depth of the specialist; it is rather that several specialists may need to attack the same problem. But more than that, the work of the several specialists must be coordinated and their skills must be meshed to maximize the net result. This is a job for a skilled practitioner. He may be an architect or a newspaper editor, a University president, or a State legislator, a research administrator or a civil engineer. But whatever his title, he needs to be capable of thinking like an ecologist--aware that there are complex systems in flux, more interested in inter-relations and processes than in things, and wise to the degree that he always asks himself: what are the ecological consequences of the proposal in front of me.

Be we civil engineers or biologists, our viewpoint must be broad for it is not possible to reach satisfactory solutions to natural resource problems without expanding the ecological concept to include man. Natural resource management usually includes matters of law, economics, politics, traditional thinking (which often is scientifically wrong), institutional restraints, and so on. Also, the materialistic aspect of the production of goods and services from natural resources often is modified by intangible values. In fact, conservation is distinguished from other kinds of natural resource management in that decision-making includes a recognition of social goals. One consequence is that the general good often runs counter to the best interests of private individuals and groups. This is why friction develops between some landowners in the prairie pothole region and biologists who want to see existing marshes maintained for wildlife production, and why a property owners association is fighting the proposed Voyageurs National Park as a "Federal land grab." It is the interplay of public and private interests that have brought about the current debate on the Ham Lake airport proposal, the heated arguments on protection of the timber wolf in Minnesota, and the wisdom of the Kindred Dam and reservoir proposal in North Dakota. In other words, the inputs to the natural resource production process include not only the natural resources and science, engineering, financing, business organization, etc., but also the democratic institutions which man has created to represent the public interest.

These thoughts can be summed up in this opinion succintly stated by Dr. Stanley Cain, Director of the Institute of Ecology at the University of Michigan. "Natural resource problems need to be viewed and dealt with in their total context, not as individual resources for single uses, but as intimate parts of the entire human ecosystem." If this viewpoint is accepted, Dr. Cain observes that there are several consequences we must think about.

"In the area of education and training, it is insufficient to produce persons only with competence in a given field. It is not enough to be an engineer or a parasitologist, an economist or a lawyer. Individuals working with natural resources need a firm grounding in some recognized and useful area of knowledge and skill, but they need also a broad ecological comprehension which, we hope, will lend them a degree of humility and produce a willingness to cooperate."

This poses a dilemma, for we are bound to see more and greater emphasis on specialization. The demand for specialization encourages narrow training; and for certain purposes of science, business and government this is useful. But our world of ever-ramifying specialities is crying out for the man who is able to see beyond his immediate job and able to understand and cope with larger relationships. Here we badly need the person who thinks like an ecologist--the synthesizer--the skillful practitioner I spoke of earlier--the man whose technical skills are matched by his breadth of understanding, by his grasp of his own heritage, by the largeness and liberality of his mind.

Turning from education to government, again the word is clear. It no longer makes sense for single-purpose agencies to go it alone on natural resource problems. We are all aware of the compartmentalized nature of natural resource responsibilities in many state governments and at the Federal level.

This has been the root of many of our mistakes and troubles in the past. The Congress and the State legislatures, and those who advise them, tend to think of natural resources as separate and isolated, and to solve problems by the same categories. Thus flood control is assigned to the Corps of Engineers, soil conservation to the Soil Conservation Service,

waterfowl to my Bureau, water use to the State water commission, and so on. Admitting that some steps have been taken to promote coordination of resource interests--most recently the Environmental Quality Act--it can't be denied that government has yet to fully understand the importance of ecology in our lives.

Thus it has developed that the Congress and the State legislatures out of reverence for the specialist--the engineer, the physical scientist, the economist--have left to him not only the task of analysis, but the actual determination of objectives and values.

From a public service point of view, those most incapable of ecological thinking are those individuals and agencies whose interest and objectives are narrow, whose problems are amenable to precise, quantitative and emotionally satisfactory solutions, and whose psychological orientation calls for unequivocal black and white answers to problems. These are the single purpose people whose skills are indispensable, but who should not be asked or expected to make broad policy decisions in the general public interest.

To make my point still another way: I would say that, generally, a scientist, as a scientist, is capable of making scientific decisions.

An engineer, as an engineer, is capable of making valid engineering decisions. There the specific competence of each ends. The same, of course, is true of a zoologist, a psychologist, or an economist. But it is not to say that an engineer or an economist, for example, can't also be a top-notch ecologist practicing his profession efficiently and also by practicing it in relation to the complexities of the real world, the general welfare, and the future good of mankind.

Most of what I've said to this point is background intended to answer the question what is ecology, and why is it important, and to remind us of some of the factors that have handicapped us in taking an ecological approach to natural resources problems.

Now, let's redirect our thinking a bit and ask ourselves: What should be the role of the engineer, and especially the civil engineer, in securing an ecological approach to natural resources problems, and what might be done to enable the engineer to fulfill that role.

Your Conference Committee has this view, printed in your program, under the heading The Engineer and The Environment: "The engineering profession must enlarge the concept of its role in society. It must throw away the last vestige of its evolution from a craft and take on the full responsibility of a learned profession. The central attribute of such a profession is responsibility, not for a segmented detail of the problem, but for an effective solution to the total problem. In the water resources planning and development field, it is abundantly clear the environmental issues are of paramount concern to society and that such concern will be an increasing consideration for civil engineers."

In the same vein, Dr. Abel Wolman, professor emeritus of sanitary engineering at Johns Hopkins University, in the October issue of the Civil Engineering magazine, in summary, writes: "To manage the environment wisely is the engineer's extraordinary challenge. For this he needs to be both Don Quixote and Sancho Panza--both the seeker of the ideal and earthy realist. ****It should not dismay the educator that his (engineering) graduate will have to master new disciplines and new skills. He will have wider horizons and be more respectful of human behavior and needs."

I suspect that some engineers might disagree with Dr. Wolman, on the grounds that managing the environment is a job for the ecologist, or some other kind of scientist, not for the engineer. It might surprise you to know that many thoughtful ecologists agree with Dr. Wolman. For example, Dr. Edward Deevey, Jr., a Canadian ecologist, writing in the spring 1970 issue of the magazine Ecology has this to say:

"No social decisions are more important than those governing the use of renewable resources. Demands are heard everywhere, especially in Congressional and other government circles, for more and better ecology. Ecologists are both flattered by these official expressions of interest and made apprehensive by them. Ecology is a supremely interesting and difficult science, regarded by its practitioners as both needing and meriting generous support. But 'more ecology' is really a demand for sound environmental management--which is not science, but a form of engineering. Unfortunately, it is a form of engineering so new, so challenging, yet so dimly perceived by the public, that to name it engineering obscures its nature. Regardless of the name, the profession is being practiced, even if not very consciously or very competently. Society needs a great many more, and abler, practitioners; and they must be better and more explicitly trained for their jobs. Ecology has much to contribute to that training--but an ecologist is no more qualified for managerial decisions about environment than a physicist is qualified to build a bridge. Ecologists are able and willing to help, but other scientists, and the faculties of most or all of the professional schools, must help too."

I am confident that under our democratic form of government, it is possible to change our traditional goals, objectives, and priorities so that Americans may lead a happy and productive life in a healthy environment; but we cannot reach that happy state without a substantial contribution from the engineering profession. The role of the engineer must be to seek and accept a higher degree of responsibility for an improved quality of life in America, not for some segment of that effort but for the total effort. This is not to suggest that engineers abandon technology. Engineers must continue to improve their technology to seek new and better means of providing essential services that are more compatible with environmental needs. This the profession will continue to do. Certainly it has a history of such effort.

But if the engineering profession is to play the more important role that it should in our society, it will need to re-examine its traditions and philosophies. The profession will need to become actively concerned with broad environmental problems. Here I'm referring to such national concerns as the presence of too many human beings in a crowded environment in some areas in our nation, while in other areas with a cleaner environment and opportunity for a good life, there is an out-migration of people. Engineers should put their logical and disciplined minds to the solution of such problems. Perhaps more important: Shouldn't the profession seek to direct its capacity to influence the development of this country so as to forestall such undesirable environmental problems? The point that I'm

making here is the same point that Demosthenes made to his countrymen 351 years before Christ when he said: "Shame on you Athenians for not wishing to understand that one must not allow oneself to be at the command of events but must forestall them. *** You wait for bad news before you act." More recently Albert Schweitzer put it another way when he said that Americans had lost the capacity of forestall environmental catastrophies.

The engineering profession must become more than a branch of technology wherein the engineer's role is to design and construct a variety of facilities at the cheapest possible cost in dollars. In assuming his more responsible role, the engineer will question and evaluate the so-called needs or demands that are projected by interests seeking more water, or cheaper transportation, or more industry, or more localized water-based recreation, or increased land values. He will test such proposals against what he knows are important environmental objectives. And he will look carefully into the ecological consequences of any proposal placed in front of him. Only by adopting this approach can the engineer determine whether, in solving one problem or meeting one need, he may be compounding an already serious environmental problem or contributing to a new problem.

How does the engineering profession go about preparing itself to carry out this new role? To me the first step is clear. The traditional basic education and training of the engineer should be broadened so that he may understand and appreciate the relationship of man to his environment, and how, in practicing his profession, he may contribute to an improved environment and a better life in America. For the undergraduate, this means curriculum changes. For the practicing engineer, it means an extension of his education through planned workshops or seminars or graduate school courses.

Second, the engineer will need to act as an advocate of his enlightened profession at the points where decisions are made. This means, for example, explaining to his businessman clients and to Congressional and legislative committees, whose views are often narrow and whose interests are too frequently localized, of the need to plan, authorize, fund and construct public projects only where they will contribute to an improved national environment as well as serve other purposes. To do this will require not only understanding but courage and patience and perseverance.

And finally, we can suggest that engineers incorporate an environmental ethic into the professional ethic that they know so well. With such a constant reminder of his individual responsibility in front of him, I am confident that the professional engineer could make a substantial contribution to the healthful and happy environment we seek.

ENVIRONMENTAL ASPECTS OF WATER RESOURCES PLANNING AND DEVELOPMENT

by Colonel Charles I. McGinnis
District Engineer
U.S. Army Engineer District, St. Paul

It has long been my belief that all of us are prisoners of our experience, so I am presenting ideas on the environmental aspects of water resources planning and development as a civil engineer and from experience gained through more than 20 years of association with the Corps of Engineers. My experience in St. Paul has been short, it has been intensive, including the planning for such controversial projects as a reservoir on the Blue Earth River, extension of navigation on the Minnesota River, a new method of planning for flood damage reduction by evacuation of the floodplain at Prairie du Chien, Wisconsin, revalidation of the Reserve Mining Company's operating permit and the conduct of a successful flood fight at Minot, North Dakota.

By the way, though I cite Corps experience as an element of my credentials, I will take advantage of the freedom of expression which I feel is appropriate to a seminar such as this one, and voice my personal opinions as a Member of the American Society of Civil Engineers, even where they extend beyond Corps policy. Please regard the pronoun "I" as referring to Chuck McGinnis, a member of the profession and "we" as meant to include all us engineers, not just the Corps.

Within the framework of this experience, and in the relative short period of my assignment to the St. Paul District, I have viewed growth of the widely-expressed concern for our environment. While some might question the motives of a few who embrace the environmental cause, there is no question of its impact or of the genuineness of the concern on the part of many. Its pervasive effects are changing such diverse activities and interests as agriculture, industry, travel, preparation for national defense, public attitudes about indirectly associated things, politics, and even the stock market. While water resources development is but a small part of human endeavor now subjected to scrutiny for its effect on the environment, it represents an activity which affects everyone. Because the water resources development field is almost entirely within the public sector the concerned citizen has given it an extra measure of his attention.

I do not suggest that I have the answers to all the questions which have been raised. These answers are yet to be found. It is a pleasure however, to share some of my thoughts with you on this subject and to discuss some interim approaches as permanent solutions are being sought.

My presentation this morning will be in four parts. First, I will discuss some of the parameters which, to me at least, help in describing the challenge of environmental concern. Next, I will talk about a few of my ideas on the apparent elements of solution to that problem. The third part will consist of a look at the future, as best it can be seen from today's vantage point. Finally, time permitting, I look forward to some discussion and to an opportunity for answering your questions.

The Challenge

The subject of environmental consideration in water resources development is not at all new. Izaac Walton, for whom one of the more vigorous conservation groups of today is named, lived during the years 1593-1683. John Muir, who founded the nationally known Sierra Club, did so in 1892. Theodore Roosevelt, a great president, and a great conservationist, was active early in this centruy. It is interesting to note that President Roosevelt's concept of conservation may have been more forward looking than some of the more popular interpretations today. He is credited with having said, "Conservation means development as much as it means protection". This thought is indeed valuable.

Lest I leave you with the impression that today's concern for the environment has nothing new about it, let me hasten to say that there are new aspects. The public attitude, as we know it today, is new. The techniques for dramatizing the environmental concern of so many are new. Certain chemical products which are purported to have a profound and persistent effect on the environment are relatively new. The increasing awareness of many thoughtful people to the need for a balance in our consideration of the environment versus development is new.

This latter point, that of a growing awareness on the part of moderates, has been born I believe, of a combination of continuing population growth, urbanization and industrialization. Though there are advocates of reversing all three of these trends, the principle is debatable and the practical means of doing so remain elusive.

The water resource planner is faced with a real dilemma in trying to meet the conflicting demands of all those who would be served by the product of his thought. He realizes that our society has expressed an apparent desire for continuous economic improvement. He observes that social and political unrest are the constant companions of arrested economic development.

The dilemma then, in part at least, is that of discerning with which voice the public is speaking. Lieutenant General Frederick J. Clarke, the Chief of Engineers, U.S. Army, recently raised this same question, and to illustrate it, explained the public outrage at a Corps of Engineers project designed to provide water for citrus fruit production. At the same time, the same public was insisting upon an ever increasing quantity of orange juice. It is a logical question, "With which voice does the public speak?"

The engineer is asked to reconcile, through some feat of magic, the public's economic needs with its desire for retention of environmental values. While seeking to reconcile economic and environmental values he must also keep in mind the political and social goals, seemingly unrelated to either the economy or the environment which are also of public concern.

I think the planner is justified in asking just which side effects of environmental preservation are acceptable to the public? Only when he has obtained answers to this question can he infallibly prepare his plans for future development. Is the public willing to accept a chronic shortage of electric power, the relocation of industry, continually rising prices, a massive increase in taxation, a chronic shortage of water, the acceptance of flood losses as a normal and necessary way of life, lowered production of agricultural activities, or delays in the means of transportation? Will the public agree to accept a reduced gross national product after so many years of conditioning to an annual increase? Is a reduction in real wages and a consistent decrease in the wage earner's standard of living acceptable? Is a reduction of corporate profits, with a consequent shift of tax responsibility from the Corporation to the individual, a reasonable price to pay for full protection of environmental values? Will the public support a reduction of recreation opportunity for large numbers of people? Will our citizens accept the discipline of dependence upon other nations for minerals essential to the public defense as a preferable alternative to maintenance of vigorous extractive industrial enterprise in our own country?

Clearly these questions do not present the only alternatives, nor is the bleak picture they describe necessarily inevitable. They represent the end of a spectrum of choice which the planner must evaluate and which must be considered in making his recommendations.

The answers are not yet clear. While we suspect that the ultimate inconvenience represented by an affirmative answer to all questions would be rejected by most people, we suspect that some inconvenience would be adopted by the majority as preferable to total disregard of environmental values.

The planner is faced with a most difficult problem in attempting to quantify environmental values. Somehow this must be done to permit comparison with other elements of the familiar benefit cost ratio. This problem is a source of concern to the citizen environmentalist just as it is to the professional planner. In recent correspondence I was asked, "In arriving at the cost benefit ratio for this project, what values were given to loss of environmental amenities, loss of alternative uses for the river and the decrease in value of other uses of the river that can continue even if the project is adopted?" It was not possible to answer this question to the correspondent's satisfaction.

Although this area is under intensive research by the National Water Commission, the answer given was that in spite of the best and most sincere efforts of many, we are not yet able to assign agreed upon values to environmental amenities.

We are not even able to discuss with certainty just which, or whose, environment we are protecting. Are we concerned with man's environment or that of lesser creatures? I suspect the answer is yes!

When considering the environment, must we accept that change per se equates with degradation? Too often I fear, the preservationist would have us believe that they are one in the same. The conservationist, in general, has been more open minded, though his attitude has hardened as the environmental crusade has increased in popularity.

Our poor engineer is faced with well known public attitudes on the one hand, and with certain facts not aligning with these attitudes on the

other. He can point, for example, to Silver Lake in Rochester, Minnesota, a lake affected by thermal pollution. But instead of the adverse affects frequently associated with such pollution, he finds a massive wild goose refuge. It would be difficult to find one naturalist who would advocate changing this "unnatural" condition.

Lest such an example be considered entirely isolated, it might be profitable to review two points of view related by equally concerned and supposedly well-informed people describing the development of the 9-foot channel on the Upper Mississippi River. In a recently issued recruiting pamphlet, the Izaak Walton League of America has this to say:

"Commercial Barge Traffic: In the opinion of the Izaak Walton River Survey Committee, management of the river in the past has been unfairly directed to give barge transportation priority over all other interests. Wing dams, obstruction of side channels, diversion of dredged silt to backwaters, proposals for flood control levees several feet higher than any recorded flood seem to add up to an attempt to shift the available water to the barge channel - while off-channel sloughs and backwaters are made more shallow and less suitable for recreation and fish and wildlife habitat."

While the Izaak Walton League has generally made outstanding contributions to the conservation movement, their position on this issue is in marked contrast with other environmental interests. An expert employed, for example, by the U.S. Bureau of Sport Fisheries and Wildlife has this to say about the Upper Mississippi River 9-foot channel now in existence:

"Thus it can be seen that impoundment by the Corps of Engineers in connection with their 9-foot channel project has created a much more favorable condition for fish and wildlife than prevailed before, and has brought about marked ecological changes on the Upper Mississippi Refuge."

Similarly the feature article of a recent issue of the National Wildlife Federation publication "National Wildlife" recognized the 9-foot channel project as an outstanding enhancement of the environment.

I suspect that in the present era of great concern for the environment, the 9-foot channel would never have been built, yet in retrospect, it appears to have been a wise investment considering both the economics and the ecology of the region in which we live.

Another part of the planner's problem is that his genuine concern for response to sincere public sentiment, must, he feels, be balanced by his dedication to protection of the public interest in spite of temporarily popular positions. It is unfortunate but I fear true, that the current concern for preservation of our environment, called the ecocraze in some recent articles, has been exploited by selfish opportunists for personal gain. These people have been clever in their use of sincere, concerned individuals and groups who have too willingly given their support.

The planner, it seems to me, has been the victim of a "crisis of confidence" which, in the absence of actual fiscal dishonesty, is the most intense in our history. This crisis is broad based: it is manifested by insistence of citizen's groups on reviewing almost every proposition presented by political leaders. It is underscored by widespread social unrest, a search for "justice" and the increasing demand for political, social and economic equality. Perhaps even the taxpayers revolt and alienation of the young are symptomatic of this crisis of confidence. The planner, working as he does in the public arena, can hardly escape the effects of such a crisis on his work.

As if our problem was not sufficiently complex because of the external factors which affect the planning process, as engineers, we must still consider the differences of opinion within our profession concerning the appropriate role of the engineer, which are adding their own measure of complexity. Mr. Samuel S. Baxter, recently installed as National President of the ASCE, was quoted in the 29 October issue of Engineering News Record as follows: "It's unthinkable that we should spend tens of millions of dollars to improve the environment for fish while in the same community tens of thousands of people live under circumstances that should not be permitted in this day and age. Fish in a stream are no compensation for people being mugged on the streets, or children without adequate food, shelter, or education." Were his thoughts converted to policy quidance, they would be unambiguous and relatively easy for our planners to comprehend.

Those who don't agree with his thinking will no doubt be pleased that a different point of view has been concisely put by the Honorable John B. Anderson, Congressman from Illinois, in his 14 October speech to the House of Representatives when he introduced the Corps of Engineers Environmental Policy Act of 1970. He said, "With the closing of the frontiers, our central challenge and preoccupation should have been to maximize resource development while minimizing environmental destruction within those frontiers. Instead, we too often proceed as if those frontiers were endless and our resources limitless. Only today we are beginning to realize how mistaken we were. Hopefully it is not too late. Our serious intentions to make this a decade of the environment could well make the crucial difference."

In addition to the ethical question posed by these disparate viewpoints, the planner, along with others of our engineering profession, must make another very fundamental decision. That is, whether they are to be technical advisors to a liberal arts decision maker, or whether they are to obtain the broadened education required to discharge their responsibilities in a professional way with respect to the whole problem.

I believe that currently we are acting too often as simply technical advisors. The profession's willingness to adopt a systems approach and to study potential development projects for the many purposes which such projects could serve, are steps in the direction of a broader and more responsible professionalism. They are but the beginning of what will be necessary to elevate today's engineer to the role of decision maker or even close confidant of the decision maker.

Water Resources Development

The above thoughts on planning may not be all inclusive, but they begin to provide a feeling for the scope and depth of the problems created by considering environmental aspects of water resources projects. Planning, preceding development as it does, is a most fruitful area for adjustment of our

attitudes toward the environment, but it is not completely effective in itself. The problem of development is related, but separate.

The major question as we consider development is that of control. Control is becoming an increasingly important function for all levels of Government in the water resources field. Typical questions raised by a serious consideration of this word are, how much control is appropriate? How and by whom should it be exercised? At whose cost? On what legal basis do we approach the problem of control? Are present laws adequate, or must new legislation be sponsored? Do we possess all of the techniques we will need to solve our development problems at an acceptable environmental cost?

I am not certain that we do. I think it entirely possible that new techniques can and will be developed which will permit an acceptable solution to a greater range of problems at a lesser environmental cost.

In the 1940's and before, all structural steel buildings were riveted. Jesse Jones of Houston, Texas, was sufficiently concerned about "noise pollution" in "his downtown Houston" that he withheld his personal authority to proceed with construction of a major office building unless a quieter way could be found to pursue it. This simple insistence on the part of a man with authority to make it stick resulted in what has become a nationwide trend toward use of welding in the field fabrication of structural steel. The point, of course, is that within limits, new and better ways can be found to solve our problems if we are interested enough to look for them.

Before leaving the matter of development, a few words on operation and maintenance of completed works might be in order. The Mississippi River 9-foot channel project is, in my opinion, a fine example of management of a completed engineering work with due regard for environmental values. This project, though originally justified and funded because of a projected economic need, has been operated with care to preserve a wildlife refuge of unparalleled magnitude.This did not happen as a simple fortuitous accident. Operations decisions pertaining to navigation pool levels, location of dredge spoil disposal areas, and other such specific concerns have been conditioned by a requirement of law to consider Fish and Wildlife values on the river. The Mississippi River flyway is tangible proof that multiple purpose development is within the realm of possibility.

The environmental aspect of development must, I think, be considered in the context of an environmental concern cycle, similar in some respects to the hydrologic cycle. The environment deserves attention during the planning stage, during construction, and during maintenance and operation. These three segments comprise the pie chart of environmental concern. Surveillance by the public and by its elected representatives represents the flue which holds these segments together.

The Solution

I promised in my introductory remarks that I would attempt to go beyond a simple presentation of my concept of the challenge. Any discussion of the solution must recognize the public pronouncements and attitudes of those responsible for finding a solution. The Federal objective for solution of the environmental development dilemma is perhaps best stated in Public Law 91-190, the National Environmental Policy Act of 1969. It says that it shall be the Federal objective to, "Create and maintain conditions under which man and nature can exist in productive harmony, and fulfill th social, economic, and other requirements of present and future generations of Americans." It would be presumptive of me to present the State of Minnesota's position on solutions of the environmental problem since Dr. Kelnhofer will talk to you this afternoon. However, from policy statements made in recent months by responsible officials one must conclude that while the State appears to have no quarrel with generalities expressed in the Federal objective, the Minnesota order of priorities of broad investment areas is weighted heavily toward environmental preservation and enhancement, pollution control, and recreational development. Water supply, flood control, and soil and water treatment are lower on the recommended scale. Navigation is not considered a likely priority in the Minnesota first assessment study.

There is no precise, mathematical way of introducing environmental aspects of water resource planning into project formulation. No two of us would be likely to come up with the same conclusion if we approached such a task independently. There is no single solution to these problems. Perhaps such a realization is the beginning of real wisdom.

As we seek a solution to consideration of environmental values in our work we come across two words which have been used with greater frequency of late for discussing an eco-system. These words are unique and fragile. I concur in the belief that proper solutions to our environmental problems must exhibit greater concern for our unique and fragile eco-systems. Too often in the recent past these words have been applied to the ecological system alone. It is my opinion that they are equally applicable to the economic system, and that a solution which seeks balance must give regard to both.

With due humility, and with an early confession that the final answer to our problems is not yet known, I would suggest some basic principles which I feel will influence our quest for the ultimate solution. First, we as engineers must evaluate the environmental impact of our project undertaking with considerable objectivity, beginning with an inventory of area resources and proceeding through a discussion of alternatives to an analysis of possible recommended solutions. We must consider a wider range of direct and indirect effects of our project undertakings. The essentiality of compromise on the part of project proponents and opponents as well, must be recognized from the outset of our planning. Those who would develop the projects of the future must seek the truth in spite of ecotactics, politics, greed, the unquantifiable nature of some of the factors considered, and the limits of both our technology and our people.

In short, we must keep our balance if we are to progress. I think that we must embrace experiment as an essential prerequisite to solution of our many problems. We must be willing to escape from the procedural and legislative limitations of the past, and we must work toward this escape through the development of new and innovative solutions to old and familiar problems.

We must seek ways to progress while our studies continue. It is tempting, in pursuit of absolute perfection, to stop all developments which could result in something less than project perfection. Unfortunately, such a

temptation does not represent a practical alternative. We must master the courage to continue our work in spite of strong forces encouraging us in the opposite direction.

As engineers, we should see a broadening of our educational base and cultivate a broad interdisciplinary approach. We must accept the need for change in our institutional relationships, both internally and in our contacts with others. We must foster an expansion of our definition of professionalism within the engineering fraternity so that our membership can continue to be recognized as capable servants of an increasingly demanding public.

Finally, perhaps to summarize all that has been said before in this list of principles, we must continue our quest for the modern "Holy Grail", that elusive thing called the public interest.

The Future

I am basically optimistic that a conscientious application of the principles enumerated above will lead us toward a solution which defines a future acceptable to all of us. I believe that organizations addressing their best efforts to water resource development will adapt and will survive. Said in another way, I consider the probability of chaos in the water resources development field to be very low. I think that the future will see a restoration of balance between the public demand for protection of our environment and its insistence on development of our resources. I think the current "ecocraze" will pass, but that concern for the environment will not. I am even hopeful that most of the selfish interests which have exploited the environmental issue will be exposed and become ineffective.

This look to the future leaves an unmistakable impression of change, and that is as intended. I think we will see changes in the amount of attention devoted to the environment throughout the development cycle of planning to operations. I feel confident that a wider range of planning alternatives will be considered. It seems clear that a diminished reliance will be placed on the economic analysis as a sole basis for judging project worth. A higher premium will be placed upon alternatives which offer an opportunity for multi-purpose development. Our planning studies are bound to take longer and be more expensive, but they are equally certain to yield better products.

A not-so-optimistic prediction, but one which I cannot escape, is that as those forces which are stimulating the changes mentioned are increasingly felt, I can foresee a surrender of previously enjoyed individual freedom to the benefit of ever increasing numbers of people. Finally, I can foresee a loss of professional status for the engineer who retreats to his technological shell.

Conclusion

Those of us who chose the engineering profession selected a field long known for its challenge. If we were honest with ourselves in making this choice, we must rejoice now because the future of challenge in our profession was never brighter. The greatest challenge is change.

The opportunity for exerting balanced, objective, and compassionate leadership to our fellow man as he seeks solutions to terifying problems has been offered to us. Failure to meet the challenge is simply unthinkable.

This concludes my prepared remarks, I welcome your questions and a chance for a few minutes of discussion.

DRAINAGE AND THE ENVIRONMENT

by E. R. Allred,
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As a member of the University of Minnesota staff, trying to serve the various interests of the people and the State, I have always been fascinated by discussions on the pros and cons of land drainage. Some of these discussions have been very lively in nature, as many of you know. Part of the problem, I am sure, occurs because land drainage means different things to different people. To the duck hunter, for example, drainage means the complete dewatering of large marshes and other open areas. This represents one extreme. At the other extreme, the farmer likely views drainage as a practice where, through the installation of underground tile, he is able to remove the excess water from certain areas of his farm. In this way he is able to plant his crops on schedule and grow the crop under favorable soil moisture conditions. With this in mind I would like to suggest that in our discussions here today we try to associate our thinking on a particular drainage issue with the type of drainage for which it applies.

As the final speaker on the panel here this morning, perhaps I can first discuss with you some of the ways in which I feel drainage can and does affect the environment. Later I will touch upon some of the charges often leveled against drainage, and finally, will make a few comments regarding the solution to problems of drainage and other ecologically related practices.

In my opinion surface drainage often presents a greater hazard to our environment than does subsurface drainage. In making such a statement I am referring to problems of excessive soil erosion which occurs so often as water runs off sloping grounds in uncontrolled fashion. Soil erosion destroys the environment not only in the field where the erosion occurred but also at the point where the soil is carried. Soil lost through erosion also represents a loss of plant nutrients, the most common of which is phosphorus. We are all aware that phosphorus is one of the nutrients which speeds up the eutrophication processes in our lakes and ponds. If we can stop soil erosion we can to a large extent eliminate the loss of phosphorus as a result of farm drainage.

In analyzing the surface drainage water flowing from field plots at the U.S. Department of Agriculture Research Station at Morris, Minnesota, Dr. Holt and his colleagues have data to show that about 0.08 of a pound of phosphorus is lost each year per acre of land. Most of this loss occurred, interestingly, during periods of snow melt runoff from grass and hay fields.

Numerous other field studies in the United States, where analyses have been made of the nutrient content of drainage water from subsurface tile systems, show that the amount of phosphorus being lost from such systems is negligible. What this suggests of course is that if we can in some manner force the water into the soil rather than letting it drain directly from the surface of the land, we would be able to filter out nearly all of the phosphorus which would otherwise be removed by the surface drainage water.

The problems of having even such small losses of phosphorus as 0.08 of a pound per acre to problems of environment and eutrophication can best be noted by a specific example. A survey was made of Big Stone Lake which forms a part of the boundary between Minnesota and South Dakota and it was estimated that out of the 90,000 lbs of phosphorus entering the lake each year 57,000 lbs originated as a result of runoff from agricultural land. Big Stone Lake has a watershed area of approximately 735,000 acres. If each acre of the land in this watershed were to contribute 0.08 lbs of phosphorus, as indicated by the Morris data, we can account for more than 57,000 lbs of phosphorus per year from surface drainage alone. A large percent of the drainage into Big Stone Lake is natural surface drainage, which has been occurring since the lake was formed. Before the white man entered the scene, all of the land was in hay, or grass crops. Consequently, if we use the Morris data, which indicate that most of the land phosphorus comes from such types of hay oriented cropping systems, we might even draw the conclusion that the transfer of phosphorus from the land into the lake was greater in the days of the buffalo than it is now.

Nitrogen is also a nutrient that can create problems insofar as drainage waters are concerned. Because nitrogen is highly soluble in water, statistics on the rapid expansion of fertilizer use in agricultural areas is often associated with increases in water pollution from nitrates. Such direct association is difficult, however, because the behavior of nitrogen in soil is highly complex. Besides the nitrogen which is added to the soil in the form of commercial fertilizers, one must also consider the organic matter in the soil and the rate at which it is mineralized, the atmospheric nitrogen, the nitrogen involved in crop utilization and leaching, the nitrogen simulated by microorganisms, and the nitrogen which is returned to the atmosphere. In a dynamic soil-plant system these processes are taking place simultaneously. Thus, when nitrate is found in water, it is very difficult to determine if fertilizers are truly the source.

In the final analysis we must be consistent in applying our control standards. Can those of us living in the city, for example, point our finger at a farmer and tell him that he cannot drain his lands because some of the nutrients in his soil are getting into our natural waterways, when at the same time this farmer sees the local governments of both Minneapolis and St. Paul applying excessive amounts of salt each winter to city streets? According to official figures, the metropolitan areas apply salt each winter at the rate of about 40 tons of salt per mile of street to which it is applied. To my knowledge all of this salt eventually ends up in the Mississippi River. I haven't figured up how much agricultural land it would take to contribute an equal amount of nutrients to the Mississippi River but I would imagine it would be well into the millions of acres. Nevertheless two wrongs don't make a right, and one must concede that, from the standpoint of nutrient loss, problems may develop from drainage on poorly managed farms.

While drainage admittedly affects various aspects of our environment, it also appears to get the blame for certain problems for which it should not be blamed. One of these is the theory that land drainage affects our precipitation. Actual precipitation records show little or no change in long time patterns or amounts. The 130-year annual precipitation average in the Twin Cities of 26.6 inches. For the first 65 years of this period the average precipitation of the Twin Cities was 26.7 inches per year.

During the last 65 years it averaged 26.5 inches. This is hardly a cause for alarm. An individual farmer, or group of farmers, cannot cause major changes in precipitation because about 85% of our rainfall is of oceanic origin and thus is carried to us by maritime air movements, much beyond the control of what an individual farmer might be doing on his farm.

The notion that farm drainage is largely to blame for our spring floods has also been repeated so often that many people have accepted it as being the truth. At first glance it may sound logical, but that is about as far as anyone can go to prove it. To my knowledge, there are no studies, facts, or data to support this belief. The real cause of spring floods in Minnesota is simply one of having heavy snowfall followed with rapid melting. This is what happened in recent years and this is undoubtedly what happened even before Minnesota was settled by the white man.

Let us direct our attention toward the possible effect of drainage upon the magnitude and frequency of floods. Are floods more frequent now than they were before drainage became a common practice in Minnesota? Again, the records indicate that they are not. Take the Minnesota River at Mankato as an example with flood records going back some 90 years. During the first half of the period, before there was much drainage, 12 floods were recorded. During the second half of the period up through 1968, 11 floods occurred. Similar results can be obtained by analyzing the flow records of both the Mississippi and the Red Rivers. Thus, it appears that spring floods on our major streams are neither more nor less frequent then they used to be.

Flow records on most Minnesota streams go back 60 to 100 years. From these we find the 1965 flood set new records at both Mankato and at St. Paul. However, the 1881 flood was just under the one of 1965 and was the largest known flood before that time. The flood of 1897 is the largest of record at most points on the Red River in Northwestern Minnesota, but this flood was way over shadowed by visual evidence of a flood which occurred at Winnepeg in 1826. If we were to check the stream flow records further we would find that the greatest known floods in the Mississippi River at St. Louis occurred in 1785. Records show the greatest known flood on the Kansas River at Kansas City occurred in 1844. If drainage is an important factor causing floods, one has to wonder what caused all these big floods before 1900?

One frequently hears the theory expressed that the reason floods occur in Minnesota is because we have drained, and continue to drain, huge areas of marsh and wetlands that would otherwise serve as sponges or reservoirs for spring runoff. This is sometimes referred to as the "sponge" theory. Let's take a critical look at this type of argument. During those years when conditions favor excessive flooding it is not uncommon to have as much as 6 inches of water drained off the watershed area. Let's assume then, that we're going to construct enough small ponds and other bodies of water so that the flood waters can be held back and thereby reduce the flood hazard. Because of the flat terrain most of these ponds will be of shallow depth, possibly averaging around 2 or 3 feet. If we are going to take a 6 inch depth of water over an entire area and accumulate it in 2-ft. depth ponds, it will mean that 25% of the total land area will have to be devoted to these ponds. What is even worse, since most of the ponds would be located in the flat areas where the best agricultural soils are also located, the amount of good agricultural land taken out of production would be much greater than 25%. Would a large number of farm ponds and potholes of this type actually reduce flood flows? They would, provided they were all empty or nearly so when the rain or the snow melt begins. This is possible, but not very likely. A saturated soil, or a pothole full of water, can't soak up water anymore than a water-soaked kitchen sponge. Interestingly, tile drainage does create a sponge effect by opening up storage space within the soil itself. The average soil in Southern Minnesota is capable of withholding between 1 and 2 inches of water per foot depth of soil. If tile drains are placed at a 4-foot depth, this would mean that we could store from 4 to 6 inches of water in the soil. This type of storage would reduce summer runoff, but of course may or may not help during spring floods depending upon the frost conditions within the soil.

Many of these marshes and potholes should and must be preserved as waterfowl habitat. They are being preserved by the purchasing programs of both the state and federal governments. The only point I am attempting to make is that in these types of programs, where wetlands are purchased for waterfowl habitat, they should stand on their own merits. We are not justified in asking the farmer, who owns and pays taxes on land, to voluntarily set aside "X" number of acres of his most productive lands so that a wetland environment can be saved. It should be possible to show that this type of habitat has sufficient benefits to society so as to justify their being left in their natural state. On the basis of the above data their existence cannot be justified from the standpoint of flood control.

We have seen several examples here this morning of where land drainage definitely affects environment. As we approach the question as to whether or not drainage as a practice should be allowed, one extreme position would be to operate under the premise that if drainage causes any change in the natural environment it should be prohibited.

On the other extreme we cannot permit or promote unlimited drainage. Where, between these extreme positions is a rational position that our society as a whole can accept? Obviously, it must be somewhere between the two. In order to arrive at an acceptable position we must be willing to make some compromise. In order for compromises to be made we must be willing to accept trade-off values between this benefit or that. What this really implies is that everyone involved in decision making processes affecting our environment, whether it be engineers, ecologists, various types of conservationists, economists, or even politicians, must discard the "tunnel vision" methods of appraisal that have been used so frequently in the past. We cannot continue to look at the end result of a proposal and assume that the end justifies the means.

Engineers as a group are trained to, and must, face hard facts. In order for the engineer-planner of today to make proper decisions, he must be certain that what he is proposing is technically feasible, economically feasible and ecologically feasible. In most cases the technical and economical feasibility can be easily ascertained. It is when we attempt to include the third dimension, that of ecological feasibility, that we begin to have trouble. What is ecological feasibility? Do we have sufficient knowledge, or hard facts to determine what is and what is not, ecologically feasible? We may in some cases, but unfortunately in most cases we do not. I am sure that attendance at conferences such as this will help us to evaluate and appreciate the ecological considerations so badly needed.

DRAINAGE AND THE ENVIRONMENT

by Walter J. Ochs, P.E.,
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The Soil Conservation Service is the technical land use planning agency of the U.S. Department of Agriculture. It is responsible for carrying out a national program of conservation and development of soil, water, and natural resources. Its policies and programs are all aimed towards sound land use planning, but people often misunderstand this when the drainage activity is discussed. I would therefore like to spend a few moments explaining our policies as related to the particular phase of our program and then provide you with some of my views on the environmental challenges for engineers working in the drainage field.

The Soil Conservation Service is in a peculiar position when discussing drainage and the environment. We are placed in this position because it is our philosophy and policy to promote wildlife habitat improvement or preservation on private lands and improve land now farmed by reducing the flooding problems, internal soil moisture problems, and erosion control problems caused by wind and water.

The organization believes in obtaining a sound balance between economic and social development and wildlife improvement in our rural environment. I support this approach as being possible and realistic. Farmers need to be able to develop and improve soils with a wetness problem when wildlife habitat is not adversely affected or when new cropland is not brought into production. Many people feel that drainage in our area will provide the economic thrust needed to slow down an increasing migration from rural America to the unemployment areas of our urban centers. Others believe that a family farm type environment must be preserved even if it means giving up some wildlife habitat.

Some believe the hunting and general recreation development on private land should be expanded and used to provide income for the rural families. I believe all of these factors are important and just point out the urgency in all of us working towards a common balance point in our future environment.

Most people agree that legislation such as the Water Bank Bill would provide a better balance in the rural economic picture and do a fine job of preserving the wildlife environment. This program would be costly, and environmental values will be weighed by Congress in considerable detail before a program of this nature is funded.

The USDA has a number of legal restraints which must be considered prior to providing assistance on drainage measures. These are:

Public Law 87-732, was passed in 1962 by the Congress of the United States. It required that requests for drainage cost sharing must be submitted to the U.S. Bureau of Sports,

Fisheries and Wildlife by ASCS for a review and a decision on its effect on wildlife habitat prior to USDA's providing technical assistance or cost sharing. This law applies to 81 counties in the states of North Dakota, South Dakota and west-central Minnesota.

The Reuss Amendment to the Agricultural Appropriations Act prohibits the use of Agricultural Conservation Program funds for cost sharing or technical assistance for the drainage of Type 3, 4 and 5 wetlands as defined in the U.S. Fish and Wildlife Circular 39. The 1963 amendment to the Appropriations Act has been included in all subsequent Agricultural Appropriations Acts and applies to the entire United States.

The environmental impact of drainage on wildlife is obvious in many areas. During most of the first half of this century, drainage activities did destroy good wildlife habitat. In recent years however, I believe this trend has been reversed and the improvement of wildlife habitat as well as preservation of existing habitat is becoming more prevalent in the minds of many rural and urban residents. We must admit that drainage has contributed greatly in Minnesota to the stable economic and social environment in our rural areas.

Asthetics related to channel improvements seem to me to be a major area where this group could have an immediate impact. Straight channels with bare steep side slopes and sediment choked cross sections are an evesore to most people. I would much rather see smooth curves along stream improvement reaches with well vegetated 3:1 or flatter side slopes.

I propose the construction of fish streams in place of ugly single purpose drainage or flood control channels. Use upstream dams to stabilize base flows. Build off stream fish ponds and plant trees around these areas where flood flows will not be affected significantly. Put your efforts into keeping the sediment from entering our stream system. Not only in rural areas but also in urban development situations. Soil particles are obviously carriers of other pollutants and to make a fish stream, erosion needs to be checked.

Engineers need to help land users assess the unreasonable demands on natural resources that are leading to the impairment of man's environment. We need to do this by providing assistance that will help these land users consider alternatives in deciding how to handle resource conflicts and prevent resource use problems. Engineers must strive to do this by more fully performing and coordinating our roles in determining feasibility of resource actions as well as providing the technology and techniques needed for various undertakings and to explain the consequences of alternative courses of action. We must all work toward greater in-depth understanding and try to convey to others the interactions and consequences resulting from resource development and conservation and its impact on the environment.

SOME ASPECTS OF DRAINAGE IN THE ENVIRONMENT OF WILDLIFE

by Burton W. Rounds,
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It is a rare privilege to have this opportunity to visit with so many of the Engineering Fraternity. It is a special honor to participate in discussions with such a distinguished slate of speakers.

I have been asked to discuss the effect of drainage on the environment. My remarks will be concerned with the effects of drainage of surface water on the environment of wildlife.

In order to appreciate what these effects can be, it is first necessary to know the environment that we are talking about and the kinds of wildlife that occupy it.

There are at least 20 kinds of wetlands in North America scattered from the high mountains to the coasts. They are occupied or visited by a vast array of wildlife--from alligators in the coastal marshes of Florida and Louisiana to moose in the edges of marshes in the Precambrian shield of Canada.

Grouse hunters know that if they hunt the edge of swamps or marshes their chances of success should be good. It is because the edges of these wetlands provide more of the plants used by the ruffed grouse for food and cover than either the wetland or upland alone.

The sporty northern pike needs grassy marshes at the edge of lakes or streams in which to spawn. When these marshes are not flooded at the right time production will be poor or nonexistent.

The mallard duck typifies the use of prairie wetlands by waterfowl. He is one of the most desired of the ducks in the Central States.

Some of the few remaining wetland meadows in Northwestern Minnesota harbor the rare prairie chicken whose booming may be heard for more than a mile, at daybreak in the spring.

Almost everyone knows that there are less than a hundred whooping cranes left in the United States. These magnificent birds use wetlands on the Gulf Coast of the United States, wetlands in Northern Canada, and wetlands in between, in the prairie states.

Blue herons make their living eating small fish and amphibians on the edge of marshes, and the marshy areas of lakes. They teach us lessons in patience and perseverance.

The avocet is familiar to those who have watched him feeding in marshes in the spring, whipping his beak from side to side as he harvests plankton from the shallow waters.

The coot is a resident of the deeper marshes in the prairie area. He goes by the rather derogatory name of mud hen. But many people value his flesh for food.

The organic production of wetland areas may far exceed that of dry lands. For example, estuarine marshes produce from five to ten tons of organic material dry weight per acre annually. By comparison, dry land agriculture produces 1/3 tons to 1 1/2 tons.

In the prairie states, areas that are often too wet for cultivation in the spring are relied upon for heavy hay crops which are harvested later on in the year when the wetlands are dry.

Rice is another example of a wetland crop.

Nodding smartweed is one of the plants which produces much food for wildlife in shallow wetlands that hold water temporarily in spring and early summer.

Walter's millet grows best in wetlands and is a favorite waterfowl food.

During the summer, wetlands often provide the most succulent grazing for cattle after the grass on the uplands has been used or has become dry and unpalatable.

With that as an orientation, I should like to discuss the wetlands of the Northern Prairie Region. These wetlands are the best waterfowl-producing areas on the North American Continent. They lie principally in Western Minnesota, the Dakotas, Southern Manitoba, Saskatchewan, and Alberta.

These prime nesting grounds produce 65 - 85 percent of the waterfowl hatched in North America in normal years.

They owe their tremendous waterfowl-producing ability to a mixture of wetlands of four primary types: They are deep open water areas, deep fresh marshes of particular value to waterfowl broods, shallow fresh marshes, and seasonally flooded basins. The shallow marshes are often overgrown with vegetation and may hold water through June in normal years. The seasonally flooded basins usually go dry after holding water for a few days or weeks following spring runoff or periods of rainy weather.

The various wetland types sometimes appear like a series of concentric donuts in a single pothole with a deep open water area (classed as type 5) in the center, deep marsh (classed as type 4) next going towards the shore, followed by a shallow marsh (called type 3), and then a seasonally flooded zone (known as type 1.) Finally, we reach the wet meadow at the marsh edge.

The injection of harmless vegetable dye into the eggs of waterfowl results in color marking of the young so they can be traced from the nest to marshes where they are reared to the flight stage. Studies have shown that ducklings will move as much as 2 miles or more from the nesting site to find a permanent marsh.

Ducklings have a tremendous food requirement. They eat duckweed floating on the surface of marshes and research has shown that they have a very high requirement for protein in their diet. This protein is provided in shallow marshes by aquatic organisms such as fresh water shrimp and other tiny fresh water crustaceans--many so small as to be almost microscopic in size.

Even though marshes used by water fowl are dry in some years, or at least during part of the year, this does not appear to prevent the areas from being useful to waterfowl. In fact, drying out seems to set the stage for waterfowl use when water returns. Tremendous blooms of the kinds of aquatic organisms beneficial in the diet of young waterfowl are fostered by the temporary drying and return of water.

There is another reason why small potholes are excellent producers of waterfowl. In the spring, pairs of mated ducks seem to require privacy that they do not need at other times. This means that they need many small water areas so pairs cannot see other pairs or similar secluded areas along the shoreline of larger wetlands where they can have the privacy they seek. They are not unlike their human counterparts on a honeymoon.

Tracts of land having the highest waterfowl production will have a central, rather permanent marsh surrounded by many small areas which provide the territory for mated pairs. The small areas may be either temporary or more permanent wetlands.

When the small wetland areas surrounding the main brood marsh are drained the ducks that would normally pair and use such marshes as private breeding and nesting sites tend not to nest. The same tendency is evident during years of drought, when the more shallow wetland areas are dry even though there is water in the deeper, more permanent marshes.

Some of the most common ducks using the prairie wetlands for production are the blue-winged teal. Other waterfowl and shorebirds using these areas include the pintail, the spectacular canvasback, the rather common, but obscure, sora rail, and the magnificent Canada Goose which is now returning to some prairie wetlands to nest under proper management.

Wetlands provide the primary natural cover for whitetailed deer in the prairie area of the United States, in summer. They provide food and cover in winter when shrub swamps and cattails are preferred habitat.

Pheasants nest in cover at the edges of prairie wetlands, especially where there are row crops on the uplands. Wetland vegetation provides excellent pheasant winter cover in both good weather and blizzards. When blizzards strike prairie areas where wetlands have been removed, the pheasants are soon dead. They face into the storm so the snow won't penetrate their feathers. The snow plugs their nostrils so they open their beaks. The snow plugs their beaks and they suffocate.

An example of the many furbearers associated with wetlands is the racoon. He provides a commercially useful fur and sport hunting as well.

Drainage of surface water by tile or open ditch removes prairie wetlands, so removes the homes of wildlife. Drainage construction often results in the deposit of mineral soil in wetland depressions even if the wetlands themselves are not drained.

Some open ditches begin to erode during heavy storms or during rapid snow melt. If they are drained into other wetland areas silt accelerates the filling in of those areas. If, instead, they empty into a stream, the silt load adds to the pollution of that stream.

Silt and farming operations can destroy the effectiveness of drainage ditches and the inoperative drainage system can then reflood agricultural land.

Drainage systems may open closed basins and, for the first time, release the water from these basins directly into natural streams. Thus they may provide new opportunity for pesticides to enter streams where fish kills can result.

When wetland wildlife habitat is drained intensively in local areas, the remaining habitat areas are subject to increased hunting pressure and are often closed by the owners to preserve the remaining wildlife or reserve the hunting for themselves.

Excavating with bulldozers and blasting with ammonium nitrate are used to construct or improve marshes to partially compensate for the marshes lost to drainage. However, such replacement may be more expensive and less effective than the preservation of natural marshes.

The most effective means of wetlands protection is acquisition and management by Federal and State Governments to reserve units of these unique habitats for wildlife and man.

Some private landowners reserve their wetlands and install contour farming practices around them, thus preserving the areas from siltation and maintaining their wildlife productivity and attractiveness as relaxation areas for man himself.

When areas are maintained by private owners for their value to livestock, wildlife receives incidental benefit.

We have been thinking primarily of wetlands as habitat for wildlife; but man himself may travel hundreds of miles to relieve the tensions of urban living, by enjoying the sight and sound of large concentrations of waterfowl in their natural habitat.

We still have time to choose whether we want to keep a mixed habitat for man and wildlife containing both wetlands and agriculture, side by side, or whether we will allow the wetland habitat to be removed to the extent that little wildlife or natural beauty remains in the prairie area.

An incentive for landowners to keep their wetlands through government payments equivalent to the net income from farming the areas may be a decisive answer in this dilemma and Congress has been working on such a solution popularly known as the Water Bank.

THE STATE'S CONCERN IN ENGINEERING PLANNING FOR WATER RESOURCES

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The topic assigned to me is listed as "The State's Concern in Engineering Planning for Water Resources". A title like that would seem to set very few bounds for an imaginative speaker. As you listen to my discourse, you will note that I have recognized no restraints in that title and have taken quite a generous view of the subject area allowed me by that assignment.

To put the topic in perspective, it might be well to begin by offering a few homilies about state government; homely truths often overlooked by water resource planners. State government is designed to serve the needs of people; not the needs of real estate or industry. It is interested first and foremost in promoting and protecting the welfare of its own state residents. The national interest and the good of the region in which the state lies are secondary considerations. State government does not deny its responsibilities to the Nation and to the region. It does not, however, subscribe to the notion that it should make sacrifices of the wealth and opportunity of its own state residents to advance the special social and economic interests of competing states and regions.

The state is also keenly aware of its important role in the Federal system. Those who do not know their history are often prone to pooh-pooh those who speak of state's rights. In their zeal for central government solutions to public problems, they tend to view the states and their established boundaries as archaic vestiges of another era standing in the way of progress. For them I would point out that the state governments created the Federal Government and not the other way around. The states are not creatures of the Federal Government as cities are creatures of their state governments. The states, it should be noted, are justly alert to intrusions on their sovereignty. It is only by such jealous vigilance that this pluralistic system of government has been able to survive the strains to which it is subject. All of you who have labored long in the field of water resource development will know that matters of Federal-state relationships are recurrent issues in water planning across the Nation.

Moving on from the state portion of that title, let me touch now on some of the problems of engineering planning for water resources. Generally, as a people, we have the money, the equipment, and the technical skill to design and construct almost any physical or engineering solution to our water problems that we may care to select. There are enough engineering marvels already in place in the United States and around the world to provide ample testimony for this assertion. If we have any significant failing in this regard it is not in our engineering abilities.

What we do share as a common failing is a tendency to take a simplistic approach to what are often rather complicated problems of environmental management. In some instances, we can excuse our rough-shod tactics by pleading ignorance. Maybe, for instance, we really should not have been expected to know the full range of the estuarine effects of our upstream dams. A recent example of such ignorance is the Asswan Dam. The Asswan Dam, built for electric power generation, "has reduced the fish population in the Mediteranean, increased the numbers of disease-bearing aquatic snails, and markedly lowered the fertility of the Nile Valley".[1/] These experiences have taught all of us to be less certain and more careful about the way we tinker with and modify nature's design. Looking about, however, one still runs across bold engineering schemes for changing the basic drainage systems of whole continents. I confess there remain ample grounds for the fear that our engineering audacity may still do us in. While we are making progress, we do have a long way to go, and the outcome of the race between wisdom and technological know-how is still uncertain.

But there is more involved than upsetting the environmental apple cart, as grim and real a prospect as that is. I would like to draw your attention to another disturbing phenomenon of the engineer at work in the field of water resources. This is the tendency to characterize most of our resource development problems as essentially technical problems which can be handled adequately by well-trained, public-spirited technicians and bureaucrats. Not only do many untutored engineers subscribe to this point of view, they also find willing allies among some segments of the public who openly profess a willingness to let the engineers decide. Needless to say, they come mostly from the ranks of those who will not be affected personally in an adverse way by the engineer's decisions.

There are many reasons why technical people should be limited in their planning role. Let's examine one of the main reasons why the technical planner should not be given the job of deciding. Basically, water is a multi-purpose resource. Almost any use we make of water affects its availability or suitability for other potential uses than might be made of it. This is a critical factor because seldom is there enough water of the desired quality in the right place and at the times when it is wanted to satisfy fully all those who would make a claim to use it. If there were, we would not need to plan. Planning for the use and development of water, therefore, is essentially a choice problem; one of allocating a scarce resource among a number of competing claimants. Believe me, this is no problem to be left to the discretionary judgment of well-meaning technicians and bureaucrats, however skilled they may be. Deciding how best to deal with floods, irrigation, navigation and similar water resource issues is usually more than the engineering problem of choosing good sites and designing appropriate structures at least cost. Most often it is a highly complicated matter which can generate considerable popular debate. It is often found that these seemingly simple engineering problems are, in fact, a mix of economics, politics, and social equity problems which have "solutions" that must be conditioned by technical requirements, financial limitations, and considerations of resource availabilities.

Water planning, in fact, is as much a political as an engineering exercise. When I use the work "politics" in reference to water management, I use it in its highest sense. It is the art of achieving a working agreement on matters which affect the interests of many contending parties. Dividing up a fixed and limited supply of water among perservationists,

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1/Council on Environmental Quality, Environmental Quality, First Annual Report, USGPO, Washington, D.C., 1970, p. 7.

conservationists, recreationists, industrialists, agriculturists, municipalities, power producers, wild life enthusiasts, and navigation interests is a disputatious task; one calling for tack, diplomacy, patience, skill, and staying power.

What is more, this is the kind of task that is never finished. Nor is it likely to be completed until the world stops changing, people and towns stop growing, technology stands still, markets become static and political balances of power are made immobile. As one observer noted,

> "---- political problems don't have solutions (only mathematical problems do). Political problems have settlements, which reflect our current perception of the problem, the current state of the art of dealing with it, and (most importantly) the temporary distribution of power among interests which are party to the settlement."2/

Planning for water resources development and management on an areal basis, metropolitan, state, or regional, is clearly distinguished from project planning by the fact that it does not end when a facility has been designed and a contract let for construction. If water resources are to be managed properly, planners cannot stop with a static plan in a dynamic world. They must continue to gather data to increase their knowledge of the problems; monitor performance to determine how well their projects are working; make surveys to keep abreast of changing needs and values; take steps to adjust supplies to demand before critical shortages develop; design for public consideration the various alternative ways of dealing with emerging opportunities or new demands; and provide sufficient information to keep the public alert to the changes occurring in the water requirements of their area.

Which leads me at last to the "State's Concern in Engineering Planning for Water Resources". The State can adopt any of a number of attitudes toward its water planning responsibilities. It can do as many of the states in the humid South have done. They have left water planning and development largely to the determination of individual local interest groups. Working through the Corps of Engineers and the Soil Conservation Service, these groups have found ways to achieve many of their special water development objectives without much help from the state.

The State, also, can do as many states in the arid West have done. They have demonstrated a deep concern for water as a basic economic development necessity. Working with other states and independently, they have built expensive water development projects, often with considerable financial help and political initiative from local units of government. They have also lobbied vigorously for national water development programs and projects that are favorable to their interests. They have cooperated closely with the Bureau of Reclamation in securing Federal funds to exploit their available water supplies for maximum development of their economies. In pursuing these important aims, they have often developed strong and expert state water management organizations.

2/Larry Margolis, Executive Director, The Citizen's Conference on State Government, quoted in Local and Regional Planning Notes, Illinois Department of Local Government Affairs, No. 24, November, 1970.

Alternatively, the state can do as states in the populous East have done. Working together with sister states in the region and with the Federal Government, they have moved beyond planning to management. As population increased and pressure on the limited water supplies became critical, the states saw the need for interstate compact arrangements to manage their region's water supplies more effectively. Federal participation in the compact became necessary as the scope of the jurisdictional area increased and the prospective funding costs exceeded the financial stake of the cooperating states.

In the Midwest, the states have demonstrated attitudes toward water management which lie somewhere between those of the industrial East and the agricultural South. We, in Minnesota, have not been very active in our concern about water at the state level. The State Conservation Service and the Corps have had, if not encouragement, little in the way of opposition from many states in the Midwest. With few water problems commanding statewide attention on a continuing basis, many Midwest states have had little occasion to build up state government organizations for water planning and management.

But that was yesterday. Changes have occurred which now promise a more active role for state governments in managing their water resources. Public concern about ecology, a popular outcry against environmental pollution, and a vast increase in demand for water-based recreation have placed new political pressures on state and local governments. The public looks to state government for responsive actions to deal with these issues. This has focused attention on the state's shortcomings in its resource managerial capacities and pointed up its undue reliance on Federal funds and programs for remedial action on state and local resource management problems.

As citizens have become alerted to their resource problems and sought official actions to remedy them, they have become aware of another phenomenon. Water resource planning, they have found to their dismay, is the special province of an elite group of bureaucrats and technicians. These water planners meet periodically and semi-privately to discuss the progress they are making in a ritualized process they have designed for deciding how water resources should be developed. The citizen, individually or organizationally, has found it difficult to penetrate to the inner workings of this planning club. His efforts as an individual or local group to influence the course of the planning work or contribute to the plan's content have met with indifferent success. He finds that planning procedures have been institutionalized which seem to relegate him to the role of final appraiser of the planners' products. He is asked, usually, to meet with the planners once before they get down to their work; telling them what he, the resident, knows of the local problems that may need the planners' special attention. The planners will call on him once more when they have completed their planning work to listen to any criticisms he may wish to make of the plans they have prepared.

Throughout this exercise, there is the demonstrated presumption that planning for water resources development and management is a highly technical operation, one to which the average lay person can contribute very little of value. This presumption has validity, however, only at that point in the planning process where the planners have been fully instructed about the objectives to be achieved, the alternative path to that objective pre-

ferred by the public, and the array of policy constraints within which the plan is to be formulated and implemented. These conditions do not obtain and that point is seldom reached in most river basin planning, metropolitan planning, state planning, or regional planning for water resource development and management. Until it does, the citizen has a large role to play in the planning process. To assure him a firm place where he can make the contribution required, there must be a fairly radical change in the way water resource planning has traditionally been done in this country. We, in Minnesota, do not pretend that we know how to achieve this change to a more open planning system. But, we do acknowledge the need and we are willing to test out reasonable approaches to that objective.

The State of Minnesota has not yet spent the time nor the energy required to have reached a consensus about what its objectives and policies are going to be in managing its water resources. A planning process has been set in motion, however, which is designed to fix the attention of State officials and citizen groups on the basic policy issues which need to be resolved if a State water management plan is to be formulated. The first step in this planning process was the preparation of a book called Background Information for Framework Statewide Water and Related Land Resources Planning in Minnesota, published by the State's Water Resources Coordinating Committee in 1969. This was essentially an inventory document, telling Minnesotans what they had in the way of water and related land resources, and the uses being made of the resources at that time. This was followed in 1970 with the publication of Minnesota Water and Related Land Resources - First Assessment. In this document, the Water Resources Coordinating Committee explained how projected changes in the population and economy of the State are expected to affect the use of the State's water and related land resources during the next fifty-year period. Potential and existing water resource development and management problems were identified along with some of the alternative solutions to them. Data deficiencies were listed and a number of basic policy questions needing early attention from the Legislature were described. The authors noted that, until more explicit policy guidance was given to the planners, there was no adequate basis for determining which of an array of possible planning solutions to water problems would be preferred by the State's decision makers. Illustrative of such policy questions are these: (1) what approach shall we favor in the use of our flood plans, i.e., should new development be restricted to prevent future damages or shall upstream control structures be built to prevent floods from damaging new development on the flood plains; and (2) shall water quality problems be dealt with mainly by low flow augmentation or by requiring more advanced types of waste treatment. Of course, there is no yes or no answer to such questions, but a policy stand will tell planners which course is to be favored when circumstances permit.

To provide decision makers with a better appreciation of how such policy choices as these will affect development options, a third report is being prepared by the Water Resources Coordinating Committee. A tentative title is "Alternative Priorities for Water Resources Programs and Projects for the Next Fifty Years". It will be released before the Legislature convenes in January, 1971. The report will describe the known feasible water resource development programs and projects in Minnesota, outlining their approximate costs and their likely effects. Contrasting projects and programs will be described, based on alternative policies, showing their comparative costs and effects as these can be estimated. From these comparisons, it is hoped that Minnesotans will be better able to choose the kinds of resource management policies which seem to them best suited to their own set of values and goals.

Another current policy question which Minnesota has before it is that of the part it is to play in Federal-state regional water planning organizations. Because portions of the State lie in four separate river basins, Minnesota has become involved with the Federal Government in a number of river basin planning organizations. Being a headwater's State and having no major water problems requiring vast amounts of Federal aid, Minnesota has little incentive to spend its scarce planning funds in supporting the work of these regional bodies. Not wishing to shirk its regional responsibilities, however, the State has joined two river basin commissions and pays annual assessments to help finance their operations. It also sends delegates to meetings of two other basin planning groups. Now it has been asked to join with the other states in the basin to establish an Upper Mississippi River Basin Commission. There is also some agitation for the creation of a Missouri River Basin Commission, whose territory would extend into the southwestern corner of Minnesota. Should Minnesota change its past policies and decide to become an active participant in the planning work carried on by these commissions, it would have to double or triple what it presently spends on these organizations. This is a complex policy problem involving considerations of state's rights, regional responsibilities, planning procedures, and development strategies. Whatever course the State chooses to follow on this matter, it is sure to produce a mix of benefits and risks, of costs and opportunities. Time and circumstances alone will prove the wisdom of the choice that is made.

Before closing, it is fitting, I believe, to make some reference to the changing climate in which the water resource planning questions facing our State will have to be resolved in future years. With all our respect for state's rights, it is becoming every day more evident that major policy decisions, eventually affecting the use of our State's resources, are being made in other arenas, often international in scope. Not only do we deal in a world where a rapidly changing technology has the demonstrated ability to reorder our traditional parameters of action, but we also become increasingly dependent upon an economic system which is becoming more integrated on a national scale. Which is to say that our freedom to choose and direct our own separate destiny is quite circumscribed today.

An example of that is currently a matter of concern in our planning for the Souris-Red-Rainy River Basins. There North Dakota would like to bring much of its land under irrigation to increase its agricultural production. Such a decision will require allocations of water supplies wanted by other states and Federal assistance funds to help construct irrigation works. Yet, the increased production potential runs into a national quota-type system which seeks to allocate a fixed-production limit among regions and states. North Dakota may rightly ask who decides that it is good to limit production of agricultural products in a hungry world and who decides that North Dakota should voluntarily produce less than some other state in the Union. This is an example of the national and international constraints which act as restrictions on a state's freedom to act independently in pursuit of its own ambitions.

There is another aspect of our water planning climate which needs to be examined. I speak now about the planners' difficulty in coming to grips with the real needs and aspirations of a society in ferment. We seem to have devised a system for planning which is better suited to a more leisurely world, one in which change comes more slowly. For example, we are now as a Nation inescapebly urban in the way we live, do business, and conduct our affairs. Yet we have come into this condition without much warning, with little preparation, and without premeditation. Steeped in the traditions of a small-town rural society, we face the metropolitan realities of our lives with institutions and expectations that prove to be more and more out of touch with our present circumstances. Water resources planning and management is one of the fields where the imperative needs of an essentially urban people seem to find too little response. The traditional resource development machinery seems to run on and on in an uncorrected trajectory while the target pursues a different path. Those who man this planning machinery appear to be attuned to the demands of an ever-diminishing portion of the electorate immersed in problems whose relevance has long since been superceded in the roster of national concerns. In a world which staggers under the undigested assault of waves of social, economic, political, and technological change, the water resource planner seems to go blithely on, unperturbed, projecting the preferences and values of past generations with little question into an uncertain and distant future. Perhaps we who work in the resource-oriented, more rural portions of this urban Nation, have a perspective which, though nationally awry, finds little challenge yet in the circles we serve.

I can say all these things to you because I am one of you and I share in the myopia and inertia which perpetuates this condition. But these mea culpas are not enough. It is not enough to point out the errors of the past, the failures of the present and confess one's share in sanctioning a common error. What is needed is to admit that much work has to be done if we are to make a new beginning; and to voluntarily assume one's share of the responsibility for seeing that it gets done. We need to innovate, turn our minds loose, free up our talents, and apply them vigorously to the task of devising better, more realistic ways of managing our water resources.

We are making a first stab at this task in February when a national symposium will be held to review the experiences we have had with the Water Resources Planning Act of 1965. The Interstate Conference on Water Problems will sponsor this examination which is designed to put the finger on the areas needing correction, specifying the actions needed to achieve improvement, and assign responsibility to particular individuals and groups to institute the measures needed to bring about the desired change. I hope you will be there to help us in this challenging search for better ways to manage our water resources.

Let us be willing, also, to spend the money that needs to be invested in research to find better methods of planning, more accurate ways of forecasting future needs; and deeper understandings of the world we would manage. Too much planning today is founded on and fed by existing stocks of information, untested assumptions, and inaccurate appraisals of future preferences. Data gathering, projections of past trends, and assumptions of a stable future are not the stuff on which to base spending plans in modern America, much less in the America we will live in the next decade and the decades after.

Let us ask all the questions that need to be asked, the bold and dangerous ones, even those that may pose some threat to our own agency and our personal economic securities. For just as sure as sure can be in this uncertain age, the questions that need to be asked, will be asked. There are no sacred havens today, no off-limits areas where we can hide our vulnerabilities. Better that we should find the answers while we still have the options; lest we wait till some one else dictates answers none of us will like.

Let me end then by saying that all of us who engage in this business of planning for environmental management need to make personal decisions to accept a proper share of the responsibility for where we are and for where we are going. It is the mark of the professional that he does not hide behind the imperfections of existing institutions, laws, customs or budgets to excuse failures in his own professional performances. We have the ability, if we choose to act, to make the contribution of experience, knowledge, and courage that is needed to remake and revitalize the environmental management apparatus of our states and our nation. Let's accept the challenge as an opportunity, which, if not seized by us, will surely pass on to others who may be less able and less dedicated than we believe ourselves to be.

SOME ASPECTS OF ECOLOGY

by Roland W. Comstock
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Thank you for inviting me to your conference today. I am faced with a difficult task today and I feel somewhat uneasy. I appear before you in a sense as a representative of an industry which perhaps more than any other in recent times has been cast in harshest terms as a wanton despoiler of the environment. In the minds of many, electric utilities wear only black hats--hats turned black by the particulate emissions many see emanating from stacks. Indeed, to an increasing number of people, all industry can be collectively lumped together as "bad guys." The difficulties of that role are compounded by the fact that here am I--an erstwhile public utility lawyer--attempting to describe the sociological overtones of the crisis about environment to an assembled group of engineering experts. Our communication difficulties under these circumstances really ought to be something else.

While there is no chalk on my suit, there may be egg on my face before we're thru. Be that as it may, I would like to share with you some guesses on why environmental concern has become a national issue. Then I would like to discuss with you the role I believe technology has had both in causing this crisis to occur and the contributions it may make toward solutions for tomorrow.

To understand what is happening requires something that both corporations and individuals don't do very well--and that is to listen and listen carefully. In the midst of all the oratory and polemics over the environmental issue, some very important things are being said. Are they being heard?

Is there an environmental crisis? Probably. Most of the major writers with science backgrounds seem to agree on that. They agree on the inevitability of results, assuming continuation of certain current conditions. They disagree on a time scale within which those results will occur (ranging from a generation or less to several thousand years). They disagree on the reversibility of results, even assuming certain current conditions can be changed. So while it is clear we probably have in fact an environmental crisis, the precise factual edges get fuzzy.

However, it is undeniably clear we are smack-dab in the middle of a "crisis about environment." I speak now about feelings and attitudes--not facts as such. We don't hear or read much about this aspect of environment--how we feel about it, what are its emotional and attitudinal dimensions and how do these affect the problem?

You see, I've now led you away from what you came to hear, so that I can tell you what I came to talk about. We've just got to start talking about environmental concern for what it is--an attitudinal set, a feeling. It's not merely an issue like Vietnam. It's a social movement with all the force for revolutionary change that concept implies. If we fail to recognize this, we'll blow it. I know of only one social anthropologist in this area who is studying the crisis about environment in this way. You saw a film by him this morning.

It is clear that the United States (indeed the world) is in the throes of a massive revolution on many fronts--and all of us share a sense of dimness. We are besieged by a host of problems too complex to understand and too remote for us to manage or influence--Vietnam, poverty, inflation, racial tensions, to name but a few. To many, it seems like a world out of control, or at least out of our individual control. And we are uneasy.

Now place the problems of environment within this context. Here again, it seems like the world out of control. But this time the issues are easy to understand and the solutions seem comparatively simple. Further, it's not some remote part of the world. It's my air being fouled, my water being polluted, my horizons being cluttered. I think it is clear the tremendous concern about environment receives a significant part of its impetus as a relief valve to express a generalized frustration about the way things are generally. It's a deep-seated expression of a compulsive need to put at least a part of the world in order. The frustration of nonaction becomes intolerable. I must be committed; I cannot remain on the sidelines.

Even on the environmental scene, the bad guys are hard to identify. The municipality 20 miles upstream which discharges raw sewage into my river seems remote--even if I know they are doing it. How many of you know whether the municipality in which you live gives primary, secondary or tertiary sewage treatment, much less what neighboring communities are doing? The thousands of cars and the burning trash barrels are nebulous targets of my frustration. But, a major corporation or industry or government is an ideal target, for it can be identified. Further, it is an institution and as one of the little guys whose world and life is increasingly being managed by others, it is imperative to shake the foundations. Further, a public utility in a sense belongs to everyone. Each month, over a million people pay us a bill. Most feel that such payment entitles them to pass judgment on the way we conduct our business.

Somewhere in this perspective must be factored the increasing youth of our people--sometimes called the generation gap. A significant segment of the young generally care very little about history or tradition or institutions. Most all young people want a better world and they want it now. Thus, our time has been characterized as one of noninvolvement with established society and of anti-institutionalism. Margaret Mead in her new book, "Culture and Commitment" points out that for the first time in the history of man, change and rate of change is so rapid there is little that is historically relevant which an older generation has to pass on to the succeeding generation in the way of moral, tradition, or custom. Even the facts we have to teach have an increasingly short life.

We see clear signs all around us--the structure of the political system is rapidly changing; the institutions of education, of organized religion are undergoing vast criticism and transformation. All around us the young, and increasingly the not-so-young, are rejecting traditional solutions and traditional institutions and traditional values. This is the real revolution! This is the real credibility gap--the gap between an ordered society and those who reject not only the solutions, but more im-

portantly, who are also rejecting the problem solving mechanisms of the ordered society. There are a great many people who feel they have something important to say but that nobody in the establishment is listening. If that is true, small wonder the crowds line up to hammer on the front doors yelling, "Why don't you answer us?" Small wonder we are thus experiencing on all fronts a withdrawal of toleration for inaction, an impatience with dialogue unaccompanied by concrete results. I consider this to be very significant in our concern about environment.

Why is the electric industry (as opposed to any other institution) on the frontiers of this issue? For two reasons, one obvious, one perhaps not so obvious. Obviously, electric utilities are physically out front. We are and will continue to be involved in a major way with the environment. The history of my own corporation clearly supports this--as the system expanded, so did the environmental controversy.

Our nation has been and is yet faced with an inexorable and accelerating hunger for electric energy. This hunger will not be abated or denied if we are to continue to be a high-energy society. Yet, there are an increasing number of responsible voices who question whether economic and industrial growth should be allowed to continue. Restated, can we have an affluent economy and high quality environment? This is the ultimate question upon which many hard social choices must be made by each of us, individually and corporately.

There is a second reason for environmental discord with utilities, less obvious, perhaps. I suggest to you that in substantial measure much of the current abrasiveness between industry and environmentalists arises because public opinion has changed the rules without prior notice. What's worse, there are for the electric industry at least four separate and distinct umpires refereeing the game: the ratepayer; the shareholder; the regulatory commission, or other governmental units; and last, the general public, which in turn is composed of several subgroups. A utility must try to serve at least four masters, each of which has a different viewpoint.

Well, does any of this concern you individually, or is it all a description of an abstract problem facing just utilities? If you were listening, I've tried to say as clearly as I know how that every institution represented in this room, the activities of which in any way directly or indirectly affect the environment, sooner or later will be facing the same issues. The Corps of Engineers in dealing with changing principles of inland waterway use, municipal governments in developing land use priorities and sewage treatment, states in setting environmental standards and building highways, manufacturers of products are all or will be in the same bag.

I think you would be making a mistake to assume that the solution to getting out of this dilemma is basic and of developing new technologies. I guess I am convinced that among our major environmental problems, with but rare exception, we know what to correct and how to correct it in a technical sense. We largely know what causes air pollution, where most of it comes from, what are its major components, what are the available corrective methods. The same is true of water quality. While there surely is much that is important yet to be learned about ecological cause and effect, how much more do we really need to know about the environment to effect technologically sound solutions? I submit that we need to know very little more.

Most of the literature and major observers state and restate the problem and point with alarm. Facts are piled upon facts. Seldom a month goes by without a new book being issued describing the problem from one viewpoint or another. One week last month seven major national magazines were all devoted to the problem of environment. I really don't believe there can be anyone who is in touch with the real world that is by now unaware of the major dimensions of the environment crisis. Yet the process of stating and restating the problem and re-identifying portions of the problem causers goes on.

Admittedly, that process is much more fun, and it certainly is easier. But I think it is time we pull up our socks and get on with problem solving. We all agree the barn is at least on fire and maybe is burning down. Now let's get the bucket brigade going. Attention has too long been diverted from the more fundamental question of how to implement what we already know and how to choose rationally among technical alternatives and their alternative costs. And that is a political and social choice process. When I say this--particularly to scientists or engineers--I am usually misunderstood. I'm not trying to say that solutions to tomorrow's problems will not require a new technology. Clearly it will. But the urgencies of time increasingly require that we cannot wait for the ideal solution, as yet undeveloped before proceeding with today's problems. This means we will sometimes engineer interim, stop-gap methodologies--knowing full well it is imperfect and will not endure forever. This means we will make mistakes--but for an increasing number of persons making mistakes is more acceptable than inaction. This means that we will spend money in less than an optimum way--we won't always get as much bang for the buck.

Do we really understand that technological answers are but the beginning--and not the end--of the environmental problem solving process? That concept is hardly perceived at all by the general public. All of us--but particularly the technologists--must recognize the environmental problem is essentially a social choice problem. We must choose among alternatives and in some cases do so very soon.

The community of science and technology must bear part of the responsibility for diverting public attention and the public conscience away from the social choice process. By the same token, the technological community also has the opportunity and indeed the responsibility to help direct our public and private concern to the arena of social choice. This responsibility falls in part upon you.

It seems to me that if the generation following is to avoid some of our current mistakes, they must have a perspective of the problem solving process not commonly found today--a perspective which goes beyond "nuts and bolts," a perspective which understands that "possible" does not always mean "probable."

We get hung up in part because we rea-ly don't have any established forums for this kind of problem solving. Our major social problem solving mechanism historically has been government. Yet by and large there has been a failure of government on all levels to produce bold and thoughtful solutions to environmental problems. The reasons for that failure are complex. In part, this failure of government is the product, in Minnesota at least, of extreme proliferation of government, particularly in the metropolitan

area. In dealing with an extensive transmission line system all within our state, we had to deal with 127 separate units of government, each one of which had a black-ball capability. To expect comprehensive planning, to expect sound decision making to occur in that kind of fragmented governmental scene is, of course, foolish. In part, the reasons for the failure of government are attributable to the general public, to the press, to the environmentalists, and yes, to industry, also, because often we do not permit government to act in a responsible and responsive manner.

The really crying need is to give prime attention to establishment of new forums which allow room for participative decision making. We must come to these forums recognizing their validity and freely surrendering the prerogative of unilateral decision making.

There are several new ways for industry to think about the environmental problems. To those industries such as ours which are heavily involved in environmental matters, there is one keystone proposition which must be understood and accepted. To many corporate executives, and I suspect to some of you, it will sound radical. The basic problem lies with the fact we make internal judgments based on our evaluations of economics and operational needs--although increasingly tempered in recent times by our intrepretation of the public will. While that basic process is obviously valid and must continue, it has one fundamental weakness. The "public" (however one may choose to define it) does not have an opportunity to participate until after the decision is made and after a point of no return is passed. Many institutions are finding this is no longer acceptable, e.g., universities, the organized church, government. The unacceptability of this "institutionalized decision making" focuses most sharply in those areas where the public feels it is most intimately involved. Thus, students and faculty feel they ought to have a larger role in university policy formation. Utility rate-payers feel they ought to be able to declare how their money should in part be spent for environmental protection. Citizens feel they have the right to judge the environmental impact caused by extraction of their mineral resources. The list of those major corporations for which the public is fast developing new definitions of corporate responsibility reads like an industrial "Who's Who."

It is a clear fact that in the future less and less will any institution be able to decide unilaterally what its particular public should have. More and more, the corporate task will be to determine what its particular public wants and then to do it! In the case of public utilities, that is another way of asking: What is the public willing to pay for? Utility obligation then will more and more involve a complete disclosure of facts, and less and less will it involve passing judgment on those facts.

This analysis produces one basic conclusion for me. Any corporate community relations program must be built on the premise the corporation is willing to significantly alter the traditional decision making process. Anything less than that is artificial and will not endure. Thus, decision making on environmental problems must, to a larger degree, be shared. And don't misinterpret this to mean surrendered. That position, if true, has tremendous impact on the way you discharge your professional responsibilities.

My own company, in an unprecedented action, announced that siting and development of all future plants and transmission lines would be discussed in advance of decision making with the public. To implement this decision we went to every major (and some minor) environmental/conservation group in the state--perhaps some 30 groups. Many of these had been and still are locked with us in bitter controversy. From each group we asked them to send representatives to a plant siting task force being formed by NSP. We tried to convey the seriousness with which the company was approaching this effort and we asked them to send people capable of making the intellectual commitment and willing to make the commitment of time. Not one group refused to participate although many were very hesitant, fearing all of this was just a public relations facade and they would be used by the company to their disadvantage. But they took the risk and the task force was formed with approximately 40 members.

The initial meetings were marked by great suspicion and hostility on the part of everyone. Each week we came to take our lumps. It was "gunny sack" time and in the eyes of some NSP people it was a futile exercise in masochism. In the group was almost every major critic of the company.

Along about the sixth week, something very significant happened. The group itself turned upon one of the more outspoken critics and in effect told him to shut up, that they felt they had a chance to do something constructive and that the constant hostility expressed by this one man was getting in the way. From that point on the dynamics of the group began to change. We also learned very early that if you are to convene a group of this kind, it is impossible to try to limit the areas of discussion. Soon we were discussing things like advertising and marketing policy and expenditures, research, rates and rate structures, validity of demand projections--things that had never been discussed at a public setting and which for many within the company produced much anxiety. All meetings were open to the public and the press was invited--no secret meetings.

The end result of phase one, that is to say, the location decision of the next generating unit--resulted in a report recommending a site that was not the company's first choice. I guess it did not surprise the pessimists. We had made clear to the task force at the beginning what our own preferences were. After a great deal of internal agonizing, the company elected to follow the recommendations of the citizen's group. While the reason for that decision is complex, it basically stemmed out of the feeling that the rationale presented by the citizen's group was the more sound.

There are all kinds of fascinating things I could tell you about other aspects of this effort. For example--the tremendous involvement and commitment to the whole process by the employees--particularly among the younger engineers. Many began to see the corporate problems beyond the art of the slide rule--and they wanted involvement. The task force continues to meet at a rigorous pace, strengthened by the company's decision and their belief that we are really listening.

The major obstacle to such an effort is distrust, and the corporation must work long and hard and patiently to overcome this obstacle. I speak now not only of the distrust by the environmental community but also the distrust that probably will exist within the corporation itself. The whole

process must be based on an implicit faith in the rational man. Once this distrust is overcome, the problems assume an entirely new scope. When there is a feeling that everybody is working toward a common objective, suddenly there is the feeling that somehow, some way, together we will make it. Gone is the my side, your side, black hat, white hat syndrome.

I think it is fair to say that by every standard--including some that were not anticipated--the initial effort of the task force has been a success both from the corporate point of view and from the community point of view. For the pragmatists in the room, there is one simple test--it looks at this point as if the company will be able to install a generating station without a major public confrontation for the first time in over a decade. But it is only a start and as with any new infant, it will require much tender loving care until maturity. It is an experimental effort to be sure.

Let me close with one last point. All of us are struggling to shape new criteria by which to judge corporate responsibility. Any such creative effort is always painful and at times, halting. Speaking for one company, I can say honestly we have a deep and genuine willingness to search for that consensus. And what better place to start than with being willing?

You are a patient and attentive audience -- Thank you!

THE CHALLENGE OF ENVIRONMENTAL CONCERN IN THE FUTURE OF ENGINEERING

by Leon Weinberger
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Gentlemen, I would like to commend the Program Committee who arranged for the program because, up until this time, it's as fine a program that I have heard of people addressing themselves with the problems of the environment. I notice in the program that my talk was to start at 3:15, and it is the only talk that there is no concluding time on. So let's see what happens.

As was indicated, I am pinch-hitting and, because of the circumstances, I did not have the opportunity of even finding out what the real theme was, but this normally doesn't bother a person like myself because even though one is given an assigned subject, I think the way we handle it can be illustrated by a story, perhaps a university story, concerned with the football team that had to be in good academic standing, so all of the football players took a course in American History. Now the reason for that was that there was always just one exam, the final exam, and the question on the final exam was always the same. The question always was: Discuss the fiscal policies under the first six Secretaries of the Treasury. So needless to say, there was no need to go to class, just prepare yourself for the final exam. This particular year, one of the stars of the football team arrived to take the final exam but, much to his surprise, he found that the question this year was: Describe the foreign policy change that took place between the Madison and Jackson administration. He pondered awhile and started as follows. He said: "The question of foreign policy change between the Madison and Jackson administration is a very fascinating subject almost as fascinating as the fiscal policies under the first six Secretaries of the Treasury" and then proceeded with them.

Those of us who, as I say, have been in this sort of thing have learned to deal with this, and my first inclination was to go to the file and pick out a talk that I gave some time back, see whether it was appropriate, and maybe simply change whether I was against and now be for, or vice versa. But, as I look at the words of the subject, the challenge of environmental concern in the future of engineering, I was somewhat fascinated with the title and thought insofar I would really try and at least hit some of the aspects of that particular subject. I, therefore, started out with the idea that the title "The Challenge" (I raised the question of whether there indeed was a challenge) - what the magnitude of it was, you know, breaking it down; environmental - what we mean by that, and was there environmental concern; the future - what do we mean by the future - is it next week, next year, 5 years from now, or 50 years from now; and even try and get into the matter of engineering. Well, I am going to try and do this. But somewhat fortunately or unfortunately, everything I would like to say has already been said by one of the previous speakers, either in their presentation or by comments from the floor or in discussions during lunch or coffee breaks. As a matter of fact, in some of my prior activities, I think I would have taken the 4 or 5 presentations and quoted from the speakers and use that as

the talk or otherwise use the old cut-and-paste technique for putting together and borrowing some ideas. Well, fortunately, I do not have a written speech, so that I have been modifying my thoughts up until now. As a matter of fact, if I do say something interesting, I'll take out my pencil and may mark it down even, or I might take off and start talking about that. What I'll be presenting to you is nothing more than a potpourri of ideas. As I say, most of these have been touched on before. What is equally surprising to me is that we're even using the same words and using the same examples. So perhaps we're getting too much uniformity in this, and maybe we've got to start changing.

One of our problems is the difference between communication and speaking. There is a lot of talk going on on the subject of the environment but, as is pointed out, I am not quite sure that we are really communicating. I am not sure that we really have the amount of dialogue, the exchange, where someone can cut you short and say, "Well, why did you say that? That's ridiculous". And you get a chance to explain what you said, and he can then ask another question. And then it may very well be that after 15 minutes or 6 sessions, you're beginning to find that maybe your views are not that different. Another aspect of this thing is the vocabulary. You've got to be very careful about vocabulary. Such words as 'good', 'bad', 'evil', 'truth', and 'fact' apparently no longer have the relevance that they once did. I'm sure this group appreciates that environmental change is quite natural. As a matter of fact, it is probably inevitable. We're not even sure whether all change is bad or undesirable.

Now, I would like to perhaps begin by talking of the various facets of environmental quality, pointing out the role of the engineer or the future of the engineer. And, if somewhere through my presentation one gets the viewpoint that I am somewhat critical of we engineers (and I will not make any disclaimer, I am willing to accept my lumps with the rest of you), and if I seem to be somewhat critical of the universities, this is deliberate. There have been perhaps 4 or 5 facets to environmental quality and environmental control. (These are not necessarily original with me.) There are the technical aspects, there are the economic aspects, there are the enforcement aspects, the planning, administrative, institutional aspects.

Insofar as the technical aspects and, here again, in talking about the engineer I am, of course, not restricting this to the Sanitary Engineer or the various other modifications of that, whether it be the Environmental Engineer or what have you. I am not restricting this to the Civil Engineer but, I think, to engineers in general. The engineer can be quite helpful in identifying technical problems. He can identify research needs. The engineer may be doing research (in other words, you may have so-called engineer-scientists). We can have the development engineer. We have the engineer who is solving defined problems through design. This, of course, may be one aspect of consulting engineering, although I would hope that we would not be limiting consulting engineering to design. The engineer is frequently (and I think this does rather well) is can come up with economical or most economical solutions to defined problems. The engineer has a role in the future and now in construction in being innovative. I might point out that one of the aspects of environmental quality control, which has been overlooked, is the fact that so much of the dollars do go into construction projects that the engineer might spend more of his time considering new methods of construction, and perhaps designers ought to pay more attention to the problems of construction and the subsequent problems of operation.

The role of the engineer in economics (economic aspects). Hopefully, the engineer could come up with self-supporting operations. He has the tools, if you will, to come up with reliable cost estimating, with the economic problems of operation and maintenance of projects. He, of course, can assist in evaluating alternative proposals for financing.

The engineer has a role also, I think, in the area of enforcement, because the engineer can be of assistance to legislators as they develop rules, regulations, ordinances, and laws. It would be real helpful if the engineer could engage in the kind of dialogue so that we end up with legislation which is technically enforceable as well as just being something we can make a law out of.

I notice in the subject matter we talk about environmental concern and not necessarily environmental problems. And so, let's talk just a moment or two about environmental concern. Well, is there concern? of course that indeed is a rhetorical question. There is concern about the environment, there is concern about the quality of our environment. There is concern being expressed by the informed, the uninformed. There is concern being expressed by the scientific and technical community, the industrialists, the conservationists, the public, the elected official. The concern is expressed in such terms as 'the world is coming to an end within the next decade'. The concern is expressed in terms as to whether or not we as people will survive. There are others who are saying that we're just going through a period of an emotional jag or a fad, that it will be passing. Now, to me as a Sanitary Engineer, it's been a little bewildering when we talk about this role or the position of the engineer in his concern for the environment because first, as a Sanitary Engineer, I thought that's what we were doing. I thought there were some people who are very much concerned with the quality of our water, the quality of our air, the problems of solid wastes, even the problems of public health, environmental health, concerned with milk, food, and various diseases. Perhaps the tools are quite limited. And even though most of the time we're trying to correct the problem rather than prevent it, the worthy engineers who, in fact, were concerned about the environment. As a matter of fact, if my recollection is approximately correct, when I started civil engineering back some 30 years ago not, it seemed to me that the Civil Engineer's role was to be concerned with the environment. I was not exposed to the idea that he was the only one to be concerned about the environment but, it seemed to me, that this is what the Civil Engineer was supposed to be doing. So that when we look at the environment, this is a totality of what we have. But I think the purpose of the meeting today is perhaps to concern ourselves with the matter of water quality, water resources, although quite clearly, there are other matters of environmental concern these days, including such things as housing, open spaces, recreational areas, highways, transportation, use of materials, cost, and again it seems to me that this was the Civil Engineer.

I mentioned earlier that I am going to be somewhat critical of the engineer and, of course, for this purpose one must generalize, because obviously within engineering we do have the full spectrum of thinking by engineers; those that are liberal, those which are reactionary, those who have been saying we've got no problems, those that suggest we have a problem of critical proportions, those who suggest the state we're in is reversible, those which say it is irreversible. I have already said that as far as the Civil Engineer is concerned I have always felt that the term 'environmental

engineering', as an example, is somewhat redundant. It seems to me that engineering, civil engineering, has a full implication of being concerned with the problems of the environment that it's just a semantic problem. I am not sure but that we may have certainly missed an opportunity as engineers in dealing with environmental problems because I don't think we have effectively dealt with the concern that's been expressed, and one of the things which I have observed is we apparently have been unwilling to employ the tools of solution which may be indeed necessary to solve the problem. We've been looking at this thing in terms of the hard, cold reality of technical solution and dollar solutions, and we have apparently been unwilling to get ourselves involved with the subject matter that's been covered this afternoon. On this matter of the political solution, the policy matters, of taking our position in a dialogue with the public, many of our people have taken the position in the past (I'm not suggesting today or this group) that if you want us to play in the game of environmental quality and environmental control, play by our rules, the engineer's rules. There has certainly been a certain amount of aloofness on the part of the engineer and, of course, although I may be a little harsh about this, Colonel McGinnis, I think, in terms of his breakdown of the engineer into technical advisors, is one group and decision makers is perhaps another, and I'm sure a certain amount of interchange. I'm not sure that the engineers, as a group, really want to be the decision makers. Now when I make this statement and, again, a couple of the speakers were somewhat apologetic for suggesting that perhaps the engineers were not the principal decision makers in all of these things. But within the last 3 or 4 months, in talking with engineering groups, when you get to consider what is involved in being a decision maker, many of the engineers have indicated that they don't consider that their role. They consider their role to be purely technical. Incidentally, I am not by any means going to try and say what we should be doing as engineers. But perhaps what I'm saying is that even the concept of referring to this profession or this group as engineers may cover such a wide divergence of activities that maybe we're looking for a new name for the type of engineer who indeed wants to participate in the decision making. There was a time that we engineers (and this I think was in the early 50's), and if you'll read through some of the older ASCE bulletins or journals in the Engineering Joint Council at the time, some of you will remember there was great concern over the fact that the scientists were getting all the credit, and the engineers were getting all the blame. Gentlemen, I have news for you. As of a few years ago, this distinction started disappearing. And accordingly, we have the same credibility gap as scientists at this point, so that much of the public is indeed very confused with the kind of technical information they've been provided with. For example, many of our colleagues took the light and ridiculing Rachel Carson. Now how would a competent scientist ever consider publishing scientific findings in a best seller? Less than 10 years later, we find that many pesticides are being withdrawn from the market. Detergents - time when people were saying we couldn't manufacture a degradable detergent. We now have a degradable insofar as the faction is concerned. As a matter of fact, I pick up the newspaper this day, and I get a little bit concerned myself. Just a few months ago, I seemed to have heard that you can't have a lead free gasoline without it costing you several cents more per gallon, and now we find that some of the companies are apparently advertising this for the same price. Isn't this a little bit confusing, do you think, to the people who are looking to us for some scientific and technical answers?

Those of us in the sanitary engineering field have kept on using the expression 'adequate treatment' or 'complete treatment' when, indeed, it was very partial treatment. We built waste treatment plants in 1955 that were primary treatment plants, and 5 years later the towns found that they had to double their expenditure and build some more treatment plants. We have some people today saying we don't need tertiary treatment, but these are the same people who said we didn't need secondary treatment, we didn't even need primary treatment. One of the rather interesting things (and again I am sorry I didn't have time to look these up, so I'm speaking of these without particular references), but I think within the last month or so there was a reference to engineering enrollments (enrollments in engineering schools), and apparently one of the fields that the enrollments are up, one of the few where enrollments are up, is in the field of sanitary engineering and environmental engineering. And this is now considered to be the glamour field. The young people are now going into this. The question is "Why now"? "Why not 20 years ago"? What were we doing at the university? And now, I am not using an editorial 'we', I'm using 'I' because I was teaching at the university 20 years ago. What responsibility did the universities have to perhaps encourage more of the students to go into this field of civil engineering at the time or sanitary engineering rather than the more glamorous field of aerospace. I think that this could be very well documented in terms of what happened.

Some of the things that have been said concerning our problems, one that comes up repeatedly, is this concept of cost benefit. Related to that is this matter of intangible benefits and aesthetic consideration. In terms of the latter two, yes, those of us who have engaged in research would like very much to have some more quantitative means of providing some values to that. Unfortunately, we don't. And if I follow what my colleagues are saying, this is when the political process comes into being.

Let me go back to the engineer again because I think insofar as this group is concerned, the thing which makes it a little bit different than any other group that one might be talking to is that I think, basically, we're an engineering audience. There is this polarization of the role of the engineer.

I have suggested that the engineer has had a key role in the past. I'm not sure whether he wanted that role or properly made use of it, or indeed whether the time is such that he can recapture this role. But I am sure that engineering, with its broad spectrum, have some people who want a key role and, most surprising to me, there are many engineers who want to have a very little role in making any of these great difficult decisions.

I indicated some of the things the engineer could do. Oh, I'm very much aware of the licensing or the professional creditation that one has, but many of the graduates from engineering school are scientists. Many of our graduates are involved in computation or design of a compound. Incidentally, I might say that the introductory statement in the program sums up an aspiration of hope that some of us have in terms of the role of engineering. But that was the role that was painted for me some 35 years ago. What happened? We have engineers today who are system designers, constructors, teachers, engineers, researchers. These are people who are dealing with one facet.

Now, one of the criticisms leveled against the people like the Atomic Energy Commission or the Corps of Engineers or the Bureau of Reclamation is that they have been carrying out their mission without being too concerned about other aspects of the problem. Gentlemen, I think that criticism is quite unwarranted in terms of a group that understands the way things are going on. I don't know if there are many examples where a practicing engineer has suggested to a city that he doesn't want to build a waste treatment plant for them because they ought to be building a hospital or a school, and that this might not be the best way for them to spend their money. Oh, I'm sure that there are some who do. But the engineer, or this man who has engineering training, that I think some of us would like to see is the planner, the manager, the implementor, the coordinator. In this case, the planner whose plans include implementation, doing something, the manager of real programs rather than theoretical or hypothetical ones, the straw man's solution that we set up and suggest that this might be a solution. But someone who is in there actually managing a project. The coordinator, to achieve workable solutions, having spent 6 years in the Federal Government, I think I've had my fill of coordinators whose entire job seems to be to coordinate without accomplishing anything. There is certainly need for coordination but with the idea of coordinating something that will work. The man I'm talking about is one who participates in a decision making process with the public officials, with the scientists, with teh economist, with the social scientist, with the man in the street, who participates in the decision making process with these people, and it has been pointed out it is a messy thing, it is very frustrating to be dealing with problems which may get to be technical and try to discuss this with people who have no technical background. But a man who wants to be an effective administrator should be doing this. The man who is questioning whether a problem exists, whether there are alternative solutions, and who will present solutions of decision makers can make their selection. At the last coffee break, we were discussing a little bit about that, actually, as it is realted to prefessors getting together, but the role of the planner, the role of the administrator in presenting recommendations of decision makers can make the selection and not be hurt when he finds that his particular recommendation is not accepted. If the engineer has a future in this field, as a man who is other than a technician, he certainly has to recognize that we're dealing with non-technical as well as technical problems. I think any contempt that he may have of the public and politicians from the point of view that our solutions are too technical to explain are going to be running into increasing difficulty. I think one of our responsibilities, if you will, is to provide our solutions, our recommendations, so that they can be understood by the people who will be making this decision. I think it is quite evident that the man on the street, the man we refer to as the layman, has much to say about what we're going to do as we ourselves.

Now the engineer, by training and education, certainly is a multidisciplinary individual. However, the engineer does not become the key man in a planning or decision making group by virtue of his education, by virtue of membership in a technical society, or because he has registration. Incidentally, he does not necessarily have correct or best answers. One of the things which he can do as well if not better than anybody else is present alternatives to solve particular problems. I agree with what has been said earlier that the mechanism for presenting of alternatives to the public or to elected officials is very difficult but, nonetheless, the engineer is very well qualified to do this. Some of the things that the engineer, or I'd like to see more engineers involved in, is in the political arena. I'd like to see more engineers try for elected office. I'd like to see more engineers accept appointed office. Now, not everyone has the talent to do this, not everyone has the real desire. I suggest we do examine ourselves, look at our colleagues and, if we do find some colleagues who have the talent, encourage them to serve. Incidentally, I've noticed in just the last two years I've been out of the government that I have fallen into (again one of the criticisms which I level at others) is that I, too, have become very negative. I find that when I see what is going on by those guys in government, they seem to be doing everything wrong. It becomes so easy to criticize. Every so often I have to catch myself and say, "God, two years ago, you were the guy who was there that was trying to accomplish something and what have you accomplished?" It isn't easy, gentlemen. But criticizing from the outside is not as useful as being on the inside. I think I have probably covered enough points to get at least some people disturbed with me. I didn't do this deliberately, I did this out of conviction, really.

I think I would summarize my point concerning engineering in that we might be pushing this thing too hard. And it's a little hard to accept that the engineer has no special role other than some of these technical areas. There are selected engineers who may have a key role, but there is one role that I would like to encourage all of us to have, and that is because I think we do have some training, some education. We are as objective about things as any other group, and that is our role as a citizen. That's one thing which no one can take away from us. I would urge each of us, now not necessarily as engineers but as citizens, to really know the problems and the issures and how to make his views known. One of the many incredible things that I have learned during the last few years is how very few of us know how the American political process works, how laws are passed, how funds are authorized, how funds are appropriated, and how we use the democratic process to accomplish our end. Now this is not a special role of the economist, sociologist, or engineer. But I think it is a role that every citizen, and we as a somewhat informed group, ought to get in there and know how to use a process.

The final point is one that was touched on by some of the earlier speakers which may very well be the key to us solving our environmental problems. And that is the creation of better institutions. It's been suggested, and I agree with this, that we probably have technical solutions to solve most of our problems now. We probably have the economic resources to indeed solve those problems. We either have the laws now or will real soon to enforce this. But one of the persistent gnawing things that one keeps on having surface is the proliferation in the effective manner of our institutional arrangements for accomplishing this. It is suggested the proliferation at the state, county, city level. I might close by saying that I would suggest that we create some new institutions with this provision: We do not create a new institution until we eliminate two of them first.

Thank you.