

U.S.G.S. WATER RESOURCES RESEARCH PROGRAM PROPOSALS

The fiscal year 1990, Water Resources Research program, Section 105 of Public Law 98-242, review process was recently completed. Submitting for research money were 123 public and private institutions for a total of 254 proposals. The total federal funds requested by these proposals was over 29 million dollars (see Table 1).

Table 1

USGS Water Resources Research Proposals: Analysis of Federal Funds Requested

Federal Funds Requested (\$):	Number of Proposals	Percent
0-9,999	0	0
10,000 -49,999	24	9.4
50,000-69,999	32	12.6
70,000 -129,999	92	36.2
130,000 -159,999	37	14.6
160,000-189,999	69	27.2

Total Number of Proposals =254
 Total Federal Funds Requested = \$29,186,528
 Mean = \$114,907
 Minimum Requested = \$10,000
 Maximum Requested = \$175,000

While the total number of proposals submitted and the total requested funding has remained nearly the same as last year, the number of institutions applying for those funds has nearly doubled which may indicate that more researchers are recognizing the significance of water resource problems. This result may also be supported by the fact that institutions in 47 states, the District of Columbia, and Guam requested federal funds (see tables 2 and 3), up from last year.

Table 2 lists the 33 universities that submitted the most proposals; they account for over 60% of the total 254 proposal submissions. Most of the universities listed in Table 2 were included in the

Table 2

Top Institutions in Submission of USGS Water Resources Research Proposals

Institution	Number of Proposals
North Carolina State University	13
Oklahoma State University	10
University of Arizona	8
Pennsylvania State University	8
University of Nebraska	7
University of California	6
Louisiana State University	6
Utah State University	6
University of Kentucky	5
University of Minnesota	5
New Mexico State University	5
University of Oklahoma	5
Colorado State University	4
University of Florida	4
University of Hawaii	4
University of Illinois	4
University of Maryland	4
Massachusetts Institute of Technology	4
South Dakota State University	4
University of Texas -Austin	4
Texas A&M University	4
University of Virginia	4
University of Alaska	3
University of Arkansas	3
University of Colorado -Boulder	3
Cornell University	3
University of Delaware	3
University of Massachusetts	3
University of Miami	3
University of Nevada	3
Ohio State University	3
Virginia Polytechnic Institute	3
University of Wyoming	3

* all other institutions submitted 2 or 1 proposals.

1989 report (*Water Resources Update* #79 p. 5, Table 2). The University of Kentucky, University of Miami, University of Nebraska, University of Nevada, Ohio State, and South Dakota State are all newcomers to this list.

One note of interest is that while the research interest in water resources appears to be growing,

Table 3**USGS Water Resources Research Proposals:**

By State	
State	Number of Proposals
California	15
Texas	15
Pennsylvania	14
North Carolina	13
Florida	12
New York	12
Oklahoma	12
Arizona	9
Colorado	8
Illinois	8
Kansas	7
Nebraska	7
Virginia	7
Georgia	6
Louisiana	6
Massachusetts	6
New Mexico	6
Ohio	6
Utah	6
Alabama	5
Kentucky	5
Minnesota	5
New Jersey	5
Tennessee	5
Maryland	4
South Dakota	4
Connecticut	3
Delaware	3
Idaho	3
Indiana	3
Missouri	3
Nevada	3
Oregon	3
South Carolina	2
Wyoming	3
Hawaii	2
Iowa	2
Maine	2
North Dakota	2
Washington	2
Wisconsin	2
Alaska	1
Arkansas	1
District of Columbia (DC)	1
Guam	1
Michigan	1
Mississippi	1
Montana	1
West Virginia	1

the amount allocated for funding by the federal government (approximately 4.3 million) dollars has remained nearly constant since 1988.

Types of Research

The research proposals were categorized into 4 major disciplines: Physical Sciences, Engineering Sciences, Biological Sciences, and Social Sciences (Table 4). As in 1989, the physical sciences has the largest number of submissions (53.9%). The biological sciences showed the greatest increase (12) in number of submissions from 1989, the social sciences had the greatest decline: only 27 proposals were submitted out of the total of 254.

**Table 4
Federal Funds by Discipline**

Discipline	Number of				Requested Funds	
	Proposals	Percent	Proposals	Percent	'89	'90
Physical Sciences	149	57.3	137	53.9	\$17,205,328	\$15,911,415
Engineering Sciences	47	18.1	50	19.7	\$5,074,778	\$5,985,079
Biological Sciences	28	10.8	40	15.7	\$2,975,000	\$4,827,366
Social Sciences	36	13.8	27	10.6	\$3,418,812	\$2,462,668

Total Federal Funds Requested = \$28,673,840 in 1989;
\$29,186,528 in 1990

Each of the four categories was further broken down into subdisciplines (Table 5). This allows us to see in which specific areas researchers are concentrating their efforts. Groundwater quality and groundwater hydrology exhibit the majority of the effort (30.7%); this pattern was also true in 1989. There was an increase in requests for microbiology and the plant and soil science disciplines of the biological sciences.

Conclusions

A major concern in the U.S. is the management and planning of our water resources. The recognition that our water resource problems are primarily managerial and/or institutional in nature has long been recognized, dating back to the National Water Commission and numerous studies and reports by task force committees. This is certainly not news among practitioners or researchers in water resources at the local, regional or federal level.

Table S**USGS Water Resources Research Proposals:
Analysis by Discipline**

Discipline	No. of Proposals		% of Total	
	1989	1990	1989	1990
PHYSICAL SCIENCES	149	137	57.3	53.9
Chemistry/Geochemistry	24	29	9.2	11.4
Water/Groundwater Quality	77	47	29.6	18.5
Groundwater Hydrology	19	31	7.3	12.2
Climate/Hydrologic Processes	25	22	9.6	8.7
Geomorphology/Fluvial	4	8	1.5	3.1
ENGINEERING SCIENCES	47	50	18.1	19.7
Agricultural Engineering	15	3	5.8	1.2
Civil/Urban Engineering	15	7	5.8	2.8
Environmental/Sanitary	17	40	6.5	15.7
BIOLOGICAL SCIENCES	28	40	10.7	15.7
Ecology/Wildlife	8	8	3.1	3.1
Microbiology	4	16	1.5	6.3
Plant/Soil Science	2	15	0.8	5.9
Zoology/Physiology	7	1	2.7	0.3
Public Health	7	0	2.7	0.0
SOCIAL SCIENCES	36	27	13.8	10.6
Institutional/Policy Anal.	13	7	5.0	2.8
Economics/Planning	20	10	7.7	3.9
Issue-Specific Management	3	10	1.1	3.9

Total Number of Proposals = 1989: 260; 1990: 254

Also, it is not news that the management problems are intensifying: traditional water allocation schemes are being revisited, new regulations at state and federal levels are being formulated, who pays and how much for additional water supply and water quality is in question, and who establishes standards and how is yet to be determined, etc. The list of these problems is growing, and requires new techniques of analysis and new approaches in arriving at decisions. No longer can water management and planning be the sole responsibility of the local or state engineering offices with advice from a traditional engineering firm. Increasingly, our urban water utilities and regional water districts are struggling with these managerial and planning problems. That struggle has resulted in a non-traditional response: those responsible for the provision of water are being forced to fund research that enables them to gain insight into their problems. Striking, however, is the gap between the

kind of research being funded by the USGS and the kind of problems our Nation faces in water management.

Last year, 14 per cent of the 260 proposals submitted to the USGS came from the social sciences; this year the social sciences accounted for only 11 per cent of the total. Last year! speculated on the reasons for the disproportionately low response from the social sciences amidst an environment which cries out for answers in this area.

Are there fewer qualified researchers in the social sciences who have an interest in water resources? Relative to other disciplines there are fewer; however, there is little encouragement for students or faculty to focus their graduate studies on research in this area. Few schools have programs that stress water management and the required social science skills. Also, the paltry amount of research funds likely discourages the competent researchers from even submitting a proposal where the success rate is abysmally low. Eventually, the water management problems in our urban areas will attract the qualified and competent researchers, as is already beginning to occur. But in the meantime, the USGS could provide leadership in this area by simply giving high priority to research on water management problems thereby encouraging the development of a new generation of researchers.

There are likely to be many obstacles to changing research priorities even though they are of national significance. Foremost would likely be professional bias: the traditional water disciplines too often observe little rigor or contribution from the social sciences researchers. Also, the social scientists as a group are diverse and many lack the requisite analytical skills. Also, the physical, biological, and engineering scientists are not trained to deal with management problems, problems which inherently require research on consumers and institutions, a totally different type of laboratory.

The USGS program could provide the leadership and influence the training of the next generation of researchers. We desperately need the analytical skills and perspective from the social sciences. And, at the same time, we need to break the traditional barriers and promote engineers to become sophisticated in the theory and techniques of analysis and the social scientists to understand the principles of hydrology, engineering, etc.

It is gravely disappointing to observe the waning interest among the social sciences in the USGS water resources research program. An effort could and should be made over the next several years to reverse this trend, and thereby addressing directly our Nation's most prominent water resources problems today and in the future.

TESTIMONY PRESENTED
before House Appropriations Subcommittee
March 8, 1990
The Honorable Sidney R. Yates, Subcommittee Chairman

UCOWR delegates **Patrick L. Brezonik, Archie J. McDonnell, and Colonel Gerald Galloway** testified before the House Appropriations Subcommittee on Interior and Related Agencies, which is chaired by the Honorable Sidney R. Yates. They testified on behalf of the Water Resources Research Institute program as authorized under PL 98-242, the Water Resources Research Act of 1984.

UCOWR as an organization, dedicated to the advancement of water resources research and water resources issues presents this testimony to the WRU readership as an example of this commitment:

“Mr. Chairman and Members of the Subcommittee:

Thank you for the opportunity to testify before this subcommittee on the subject of appropriations for the Water Resources Research Institute Program as authorized under PL98-242, the Water Resources Research Act of 1984.

I am Patrick L. Brezonik, Director of the Water Resources Research Center at the University of Minnesota. My testimony is on behalf of the National Association of Water Institute Directors (NAWID), National Association of State Universities and Land Grant Colleges (NASULGC), and the Universities Council on Water Resources (UCOWR). Together these organizations represent all of the nation’s universities with major programs in water research and graduate education.

As chair of NAWID, I represent the 54 Water Research Institutes funded by the Water Resources Research Act and located at land-grant universities in each state and four territories. My testimony was prepared in cooperation with Archie J. McDonnell, Professor of Environmental Engineering at Pennsylvania State University and Chair of the NASULGC Committee on Water Resources, and Gerald Galloway, Professor and Head of Geography and Environmental Engineering at the U.S. Military Academy and President of UCOWR, an

organization of about 85 of our leading universities engaged in research, education, and public service activities related to water. As representatives of the above organizations, we are united in our concern about the quality and adequacy of our nation’s water resources and in our commitment to promote quality research, training and outreach programs directed toward water resources issues. We also recognize the need for better federal and state support for water research and education.

Re-authorization of the WRRRI Program is being considered by Congress in this session. By a wide margin, the House passed a reauthorizing bill sponsored by Congressman Miller (HR. 1101) in June, 1989. The Senate currently is considering several bills. S.714, introduced by Senator McClure, has 57 cosponsors; however, the Senate Committee on Environment and Public Works, to which it was referred, has not yet acted on it. We sincerely hope that the Senate will act this session to reauthorize the Program so that it can go forward with a renewed mandate to meet the water challenges of the 1990s.

Abundant and high quality water resources are vital to the nation’s well being, but these resources are threatened on many fronts. Water quality concerns have been paramount in recent years, but recent droughts have refocused long-

standing concerns about water availability. Predictions of global climate change suggest that water supply management may be an even more pressing issue in the future. Public concern about water quality and availability remains high, and despite extensive efforts to solve these problems, much remains to be done.

The nation's universities, especially its land grant institutions, play three vital roles in identifying and developing solutions to water resources problems. First, they conduct much of the basic and applied research on water issues, thus improving our knowledge and finding new ways to solve problems. By using students for much of the work, they do this in a cost-effective manner. Second, universities provide training for most of the water professionals employed by public agencies and private industry. Third, universities play major roles in public education and information transfer among water professionals.

Role of the Water Resources Research Institutes Program

The WRI Program was initiated by the Water Resources Research Act of 1964. The decision to locate an Institute in every state was based on the need to assist state and regional water agencies; every state has water resources it must manage. Every state also has a land grant university that conducts graduate research and education related to water resources. The network of WRRI effectively conveys information on research needs and results among states and between the states and federal government. The WRRI thus are a key interface between national concerns and local needs. Since 1983, the WRI Program has been managed by the U.S. Geological Survey, and much progress has been made in coordinating activities of the Survey and Institutes in the past few years. Cooperative programs between WRRI and USGS District Offices are common, and coordination of the two programs at the regional level is underway.

Research

The Water Institute Program celebrated its 25th anniversary last year, and as part of the celebration, NAWID developed a commemorative booklet, handbook and video describing from a national perspective the program's past accomplishments and current activities. The booklet confirmed what most of us already knew; the WRI program has been an important force for high quality, academic research on water problems and has produced findings with major impacts on the way the country's water resources are managed. The prominence of the WRI Program belies the modest proportion of federal outlays for water research it receives. The Program produces a significant fraction of the literature in water disciplines and has trained thousands of active water professionals. NAWID recently gathered information on the numbers of articles and reports resulting from WRI projects funded since the 1984 reauthorization. With the help of the USGS, NAWID is analyzing this information to produce a national perspective on WRI research. Although the analysis is still underway, I can say that the lists of the WRRI provide impressive evidence of the vitality and accomplishments of their programs.

Research activities of the WRRI extend beyond the universities at which they are located. WRRI cooperate with other universities in their states and fund research projects at non-Institute universities. In 1989-90, over 70% of the federal funds each institute received is being used for direct support of research projects. Projects funded through the WRI Program are peer reviewed for technical merit and reviewed by advisory committees for relevance to state needs. The review process encourages objectivity and selection of projects on the basis of both merit and relevance. The programs in each state are highly competitive; Institutes typically have funds to support only one out of every four or five proposals submitted to it. On a national basis, the program is funding 266 projects on 106 campuses in 1989-90. The number of participating universities would be higher, if matching fund requirements for the program were

less severe and funds were not so limited. At present, a match of \$2 nonfederal; \$1 federal is required. Although the nonfederal match is on a programmatic basis rather than on individual projects, most WRRIs require other universities to produce their fair share of matching funds since host universities are not able to subsidize them for the matching funds. As the matching requirement has increased, the program has become less attractive to other universities, especially private ones, who would rather use their resources to leverage federal funds from programs with lower matching requirements.

Training/Education.

More than 30,000 students have been supported by working on Institute-funded research projects, and over 90% of them have stayed in water-related fields. Inflation has eroded the value of federal appropriations for the WRII Program by a factor of three over the past 20 years, and as a result, the number of students supported by WRII projects has declined from about 1,700/year in the early 1970s to about 600/year during the late 1980s. In contrast, the need is increasing for professionals in water related disciplines, especially those related to groundwater pollution. Several recent studies have concluded that a shortage of scientists and engineers trained in hydrogeology and aquatic chemistry will hinder efforts to protect groundwater. Expanding programs for water management and environmental protection at all government levels will require additional professionals in coming years. Unless increased funds are available for graduate training in relevant fields, academic programs will not be able to attract enough students to fill these needs. We recognize the role of states in funding graduate work in areas of critical need. At the same time, we note the long-standing role of the federal government in supporting graduate research and education in areas of national concern. Because federal agencies employ large numbers of water professionals, there is equity in the concept of federal assistance in training these individuals.

WRRIs are playing increasing roles in information transfer and in communication between academic researchers and research users in agencies and industry. Most WRRIs publish newsletters to communicate with professionals and the public. Many WRRIs publish circulars to explain water issues to the public, and some produce videos on critical water issues. The WRRIs develop and distribute technical reports, computer programs, and data bases useful to water scientists in academia, government agencies, and the private sector. Most WRRIs sponsor conferences that bring together agency managers, consultants, and researchers to discuss new findings and information needs. Institute directors serve on task forces in their states and provide communication links between academic researchers and management agencies. The information transfer accomplishments of the WRRIs are significant, but the Institutes are ready to do more. Consequently, we are seeking a more formal information transfer program in reauthorizing legislation.

Current Emphasis Areas of the Water Institute Program

Located in each state and in touch with local situations, the WRRIs are at the forefront in recognizing impending problems. For example, much public attention has been directed at the contamination of groundwater in recent years. The WRRIs recognized this emerging concern in the early 1980s and have directed an increasing proportion of their activities toward this area. WRII programs funded 79 projects related to these problems in FY 1988, which ended in summer 1989. In the present year, 93 projects (over a third of all projects funded) are related to groundwater issues. Topics include transport of water and contaminants into aquifers, sources, levels, fate and effects of contaminants, management and prevention strategies, and remediation methods. Collectively the WRRIs represent a significant, ongoing program in groundwater research, and they would do more if more

funds were available. The WRRIs also promote public education and information transfer on groundwater problems. Several Institutes sponsored workshops on these problems in the past year. The Midwest WRRIs held a successful regional conference in November 1989 to share information on the implementation of federal and state groundwater management strategies.

Water availability has re-emerged as a major problem. The current droughts are short-term examples of this issue; effects of global climate change is a long-term concern. WRRIs have funded research on drought management and water use efficiency for many years. Numerous accomplishments and examples of WRI activities on these topics can be cited. For example, the North Carolina Institute developed a model that was used to manage water resources in the Raleigh-Durham area during the 1988 drought. Research in New Mexico is developing drought-resistant crops by use of biotechnology and genetic manipulation. A Mississippi project evaluated management strategies used nationwide during drought/emergency conditions. A project in Washington is producing a computer-based "expert system" to aid in drought management planning. Research in nine states is aimed at improving irrigation efficiencies for different kinds of crops. The Colorado Institute recently assessed the willingness of water managers and water users to commit public funds to achieve various levels of water supply reliability. Connecticut researchers developed a hydrologic model that can be used to predict local hydrologic changes for various climate change scenarios, and researchers in Connecticut and Minnesota currently are studying impacts of projected climatic changes on streamflows in those states.

Other emphasis areas for current research include nonpoint source pollution (17 projects in 1989-90), agricultural management practices in relation to water quality (12 projects), and fate and effects of pesticides in natural waters (27 projects). WRRIs also are important sources of funds for research on improved treatment methods. This is noteworthy since funds for such work from the U.S.

EPA have diminished in recent years. Recent WRI projects on treatment technology have developed methods to degrade toxic organic compounds by photocatalysis and to recover cyanide from wastewater by using hollow fiber membranes. Ongoing projects in five states are aimed at biological removal of nitrate from agricultural runoff, septic tank leachate and contaminated groundwater.

Recommendations

* We request \$10 million in FY 1991 for the Institute Program (Section 104b of P.L. 98-242), providing each Institute with \$185,000 to continue the federal-state cooperative effort that has been productive for 25 years.

* \$5 million is requested for a new competitive Institute-USGS focused research program on critical regional water problems such as groundwater contamination and effects of climate change on water resources. This program is Section 104g of reauthorizing legislation pending in Congress.

* We request \$10 million for the section 105 program. About \$40 million is requested annually by proposals to this program, and many worthwhile and needed studies go unfunded.

* To facilitate the transfer of research results, we request \$2.7 million for Section 106 to enhance information transfer activities and initiate a formal information transfer program in the WRRIs.

* We request \$800 thousand for USGS administration of the program and request that an amount equivalent to 1% of the 1990 Section 104 and 105 appropriations be allocated to analyze the accomplishments of the 1990 programs.

We recognize that these are austere times and that our request for increased appropriations does not make your budget-balancing task easier. However, we ask you to remember the serious needs for training and research on the nation's water problems and protection of its environment

and the abilities of the WRRIs in solving these problems. We appreciate the support our program enjoys in Congress, and past support by this subcommittee. However, we want to remind you that the program has had level funding for many years and inflation has caused a serious funding decline in real terms. We are concerned that without Congressional adjustment for inflation-induced funding losses, the ability of the WRRIs to do the

jobs expected of them is being diminished. We are reaching the point where the vitality of the program is being compromised. We are proud of the accomplishments of the WRRIs and stand ready to work with others toward the goal of clean and adequate water for everyone. On behalf of my colleagues and our organizations, I thank you for the opportunity to appear before you.”

ENVIRONMENTAL ERA ISSUES

INTRODUCTION

Jon F. Bartholic

UCOWR President-Elect
Michigan State University

In the media, or as we talk to legislative and industrial leaders, the decade of the 90s is oft times referenced as the decade of the environment. Clearly, surveys of public priorities, interests, and concerns place environmental quality and related issues either at or very near the top of the public's list of priorities. Increasingly, TV documentaries are being developed that feature the unique nature of our planet, the threats to biodiversity, the "ozone hole" danger, and the list goes on. The popularity of the environmental movement is perhaps best seen in the number of prime time TV shows that are developing themes around environmental issues. Water issues are clearly a cornerstone of these concerns and activities.

Increasingly, federal, regional, and state programming involves new emphasis on environmental issues. Air quality, acid rain, and surface and groundwater concerns top these lists of initiatives. Simultaneously, there is an increasing awareness in some circles of the widening shortfall of scientific capacity to address these important issues.

UCOWR, with its networking of over 100 U.S. universities and foreign affiliates, is in a key position to facilitate the coupling of university strengths in education, research, and outreach with a new public and federal environmental agenda. A vital need exists to continually communicate and educate our federal, regional, and state leaders about the strengths and capacities within the UCOWR member universities. This will lead to an enhancement in the productivity of these organizations while strengthening universities' scientific capacity and ability to train students.

To this endeavor, *Water Resources Update* is devoting this issue to the theme of The **Environmental Era**. We are indebted to the authors who have taken time to share with us the emerging applications and implications regarding this topic.

**KEYNOTE ADDRESS PRESENTED TO AMERICAN SOCIETY OF
CIVIL ENGINEERS'
ANNUAL CIVIL ENGINEERING CONVENTION AND EXPOSITION
NEW ORLEANS, LOUISIANA**

Lieutenant General H. J. Hatch
Chief of Engineers

United States Army Corps of Engineers

It is a particular privilege for me to be with you today, and I look forward to another opportunity to share with the Society some issues that I believe are of our common professional concern. I intend to share with you some of my thoughts about our changing world and the opportunities and responsibilities facing civil engineers as we strive to be creative, in building a better world and building a better America. I will talk about all engineers; not just the Corps, but, of course, that is my primary experience and my primary reference point. So I will include a little bit about what our organization is doing as we look to the future.

I am going to talk about what I respectfully submit to you is the engineering issue for the '90s and beyond . the issue that will challenge our creativity and must be addressed if we are to achieve a better world in the next century.

Engineers should take great pride in the role that we have played in developing our civilization and our nation. It is impossible to even conceive of what the world would be like without what civil engineers have produced and the resulting economic growth and social and economic well-being. I am particularly proud of your Army Corps of Engineers. The Corps is the oldest engineering organization in the nation, one whose history is inextricably tied to the development of our country. We built early forts for defense and roads for commerce. We identified the value of and managed Yosemite National Park and preserved its beauty long before we had a National Park Service. We developed the waterways for navigation. We built

levees and dams to protect lives and property from floods and built military bases to defend our country. We built the support facilities for the space program. And in the support of our foreign policy, we have built infrastructure for other nations and, more importantly I believe, we have developed their capabilities in engineering and construction to promote their stability and growth.

When I say we, I include, of course, the private sector as well as the Corps. When I talk about Army engineers . forgive me . but I include you. I talk about the three components of Army engineers, and we have always had the three. Right now, we have about 100,000 engineer soldiers in uniform, two thirds of which are in the reserve components; about 100,000 Army civil servants; and, at any time, about half a million civilians, here and abroad, working for the Army as part of that Army engineer team through the vehicle of the contract. So you are very definitely a part of that team.

All of this development was in response to real and perceived needs and contributed markedly to the health, prosperity and security of our people. For our nation's first 200 years, engineering . civil engineering . and development were essentially synonymous. In the late '60s and '70s, however, our nation recognized that continued development must be tempered by a concern for the environment. We had overloaded ecosystems. Hence, mitigation and environmental compliance became a part of our vocabulary and our professional practice.

Now, today, after a few years of quiescence, I believe, the environment is receiving renewed attention as an area of serious concern, nationally and internationally, and has received renewed emphasis from President Bush. The reason is that research and monitoring around the world have signalled that the exponential increase in human activity on our planet is straining the ability of the life-sustaining processes of the natural world to continue to regenerate. Not only are we learning what is happening, we are learning the consequences of it. We are learning that human activities - for example, the use of chlorofluorocarbons and the destruction of the rain forests - are actually affecting the climate on planet Earth, with implications ranging from energy consumption to agriculture. The President has committed us to the phaseout of those chemicals by the year 2000.

Another example particularly appropriate for us to consider as we meet here in Louisiana is the loss of coastal wetlands or tidal marshes. The United States, as a whole, has lost over half of the wetlands that existed when the Pilgrims landed at Plymouth Rock, and we continue to lose nearly half a million acres a year. Here in this area, in response to needs for flood protection and to develop our vital navigation linkages to world markets, we built levees and deepened the Mississippi. Now, just here in Louisiana, over 35 square miles of marsh are lost every year, the victim of natural processes and changes caused by flood control levees on the rivers that previously replenished the nutrient-rich sediment of the marshes, and other activities. But only in the last few decades have we come to recognize the value of those coastal marshes - the value of those productive ecosystems, such as the role they play not only in the life cycle of shellfish but in flood protection and hurricane protection as well. Waste disposal is another issue. And I could go on.

The bottom line is that our planet has serious environmental problems. At the time of his first budget submission to the Congress and the American people on the ninth of February of this year, President Bush issued a report called "Building a

Better America" (we engineers should like that title!). The President didn't say "Preserving" one, he said "Building" a better America. In his speech to the United Nations last month, he again drew attention to the global aspects of these problems. He pointed out that the environment belongs to all of us and noted that the United States has begun to explore ways to work with other nations to make our environment a common cause.

So I believe that the environment is the most significant engineering issue of the next decade and into the next century, not to the exclusion of other issues, but one that presents the greatest challenge and opportunity to civil engineers. It is we engineers who hold most of the keys to the solutions of the world's environmental problems. Without us, they will not be solved.

Note, however, that development will and must continue. The population of the world will double sometime in the next century. To support that population, our economies must grow five to ten times in that same period. Today, there is no responsible consideration given to a no-growth policy. Economic growth is not only inevitable, it is necessary, and paradoxically, as I will point out in a moment - economic growth is necessary to conserve the Earth's environment as well. So the challenge to all of us is to achieve growth that is environmentally sustainable, that does not exceed the ability of the Earth's natural processes to regenerate themselves: for the rain forest to regenerate, for agricultural land to retain its topsoil, for the air we breathe and the water we drink to be life sustaining - not life threatening.

This notion of sustainable development received public attention in 1987 when the World Commission on Environment and Development called for a new era of economic growth - growth that enhances the resource base, rather than degrading it. The Commission described environmentally sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

So my purpose is to point out that the success of environmentally sustained development depends on creative, environmentally sensitive engineering. It depends on engineering that looks beyond the immediate problem, the immediate gain, and considers the long-term and wide-ranging effects.

Now, some in our profession will question that. They see the role of the engineer as that of essentially a technician who is only concerned with the narrow scope of the immediate and not the second and third order of effects over a long period of time. We engineers must look at our work in a broad social and environmental context as well as in technical and short-term economic terms. The professional engineer must look at the problem in its broadest context and ensure that decision makers are aware of the consequences of a wide variety of possible solutions. The key to that is wise planning at the outset and integration of environmental thinking with engineering thinking. We must widen our vision to see the broader consequences of our actions and to see broader possibilities for innovative solutions.

Now, little I have said to this point is really more than to emphasize the strengthening and broadening of our resolve to be environmentally compliant . something we learned to do in the late '60s. Environmentally sustainable development leaps beyond that to directly anticipating and solving environmental problems.

Environmental engineering, in its broadest definition, must not only mitigate environmental costs of development, but must also directly attack environmental issues as a purpose for the engineering effort itself. The two together can yield development that can be reasonably considered environmentally sustainable.

For our first 200 years, the Corps of Engineers pursued a basic development mission, responding to our nation's needs, domestically and for defense, and in direct response to our Presidents and our Congress. In the late '60s, in response to a changing national will and Congressional mandate,

the Corps of Engineers overlaid onto its developmental bent an environmental sensitivity. We hired biologists and ecologists and sought environmentally acceptable solutions and mitigated damages caused by development. We began to change the very character of our organization, yet we remained basically a developmental organization that designed and built environmental value into its projects.

I am now challenging our Corps by saying that simply overlaying an environmental sensitivity and consciousness on our developmental activities is insufficient to meet our nation's and the world's needs. Environmental ethics and values must be more than an overlay. They must be a bone-deep part of our foundation ethic and part of our way of doing business.

To achieve environmentally sustainable development, we must forge partnerships with environmentalists as well as with those who pursue development. We have a common concern with environmentalists: the health of our planet and the health and prosperity of our people. We both must be guided by a common ethic that emphasizes sustainable development, based on sound economic and sound environmental principles.

I believe the concept of environmentally sustainable development can be the unifying ethic that will reconcile these disciplines where they have not been already. Engineers and environmentalists must stop thinking of each other as adversaries and see each other as partners with complementary expertise. Many of contemporary society's environmental problems cannot be adequately addressed without this cooperation. On the other side, I believe, environmentalists have failed miserably in exploiting the nation's engineering talent . while engineers have missed both economic and service opportunities as well.

If engineers accept the ethic of environmentally sustainable development, then, for example, our efforts to restore our aging national infrastructure should not be perceived as an onslaught on the

environment. Indeed, the rehabilitation of infrastructure provides an opportunity to restore the national environment as well as to provide the necessary foundation for our economic health.

In meeting the challenges I have outlined, the Corps has a special role to play. The Corps still thinks of itself- and I believe with some justifiable pride - as a “nation-building” organization. But nation building means something quite different today than it did 150 or even 50 years ago. Nation building no longer automatically means large construction and maintenance operations. Today, environmental issues are some of the world’s most critical public works challenges. The Corps is ready to use its engineering capacity - and is being called on today - to help create a future that is economically sound and environmentally sustainable. In short, I see the Corps’ future as an environmental engineering organization. . . as well as a development organization. . . as well as an agent to protect our nation’s security.

The Corps’ traditional strengths in project management, planning, design and construction will be essential to meet many environmental challenges. It is our hope that in the future environmentally focused organizations will work with us and you for engineering and management assistance, just as development organizations traditionally have.

The Corps is re-examining its mission and mustering its energy to enhance environmental quality while contributing to social and economic well-being. We are not seeking to become the

nation’s environmentalists. Our business is building for peace and public service. We believe that development is absolutely necessary for both, but I am committed that the development in which we are engaged be environmentally sustainable.

Environmentally sustainable development is the key, and your civil engineering skill is essential.

There are many opportunities. I think “opportunity” is the operative word. Many of you are now experiencing the economic opportunities in at least some narrower aspects of what we now call environmental engineering. But I believe we have a broader opportunity to reestablish or regain some relevancy in our society that, at times, we seem to have lost. It is an opportunity to excite our society in our profession, to increase the interest among our young in engineering because they sense we are directly relevant to the problems they believe our nation and the world faces. Accordingly, it is an opportunity to increase the numbers of graduate engineers who will strengthen our nation in international peacetime competition.

In summary, now is the time to use our engineering capacity to advance environmental goals.

Now is the time to consciously choose and create our future.

For today, we recognize that sustaining the environment is a necessary part of building this nation . . . and every nation on this planet.

STRATEGIC DIRECTION FOR ENVIRONMENTAL ENGINEERING

Lieutenant General H. J. Hatch

Chief of Engineers
United States Army Corps of Engineers

The Army Corps of Engineers is entering an exciting new decade as we witness the greatest changes in the international order in years, perhaps our lifetimes. It is a time to reflect on our 200-year tradition of service and prepare ourselves for yet greater service in the nineties and beyond. This letter focuses on what I believe will be our greatest challenge, opportunity, and growth area. While the emphasis on various components of our national security and our Nation's well-being are changing, one element emerges in relative importance—not only in the United States, but throughout the world—our environment.

We in the Corps are justly proud of our role in developing and defending our Nation in the last two centuries and of our response and adaptation to a growing national concern for environmental values. In this era of ever increasing change, “response and adaptation” are not adequate for contemporary needs. The present lead times involved in changing the direction of our institution with the momentum of our legal, regulatory, cultural and budgetary bases for conducting our business are just too long. We must establish a new strategic direction that will guide current and future changes in all aspects of our program, civil and military. These changes will be fully consistent with Administration policy and in accordance with both the spirit and the letter of the authorizations provided by Congress.

The National Environmental Policy Act (NEPA) remains our broadest guide for action. Twenty years ago, the President and the Congress declared that it was the continuing policy of the Federal Government to use all SUBJECT: Strategic Direction for Environmental Engineering practicable means, “to create and maintain conditions

under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans.” (NEPA, Section 101) President Bush and Secretary of Defense Cheney have specifically declared their dedication to a sound environment. President Bush, for example, in a speech to the United Nations on 25 September 1989, identified the environment along with economic and security issues as the top global challenges of the 21st century. It is increasingly clear that our security relies on a healthy natural resource base. On 10 October 1989, Secretary Cheney stated his vision for how the Department of Defense would meet the environmental challenges it faces. He called on the DOD to be the “federal leader in agency environmental compliance and protection” and to be committed “to meet the worldwide environmental challenge.” Therefore, to meet our Nation's and the world's needs, an environmental ethic must be an integral part of how we conduct our business. It is the Corps' obligation to protect and restore environmental quality while contributing to social and economic well-being.

In practical terms, embracing and promoting our environmental ethic and spirit will change the way we do our traditional business and work for other agencies. As our history demonstrates, we have a unique tradition and capability to solve engineering, environmental and developmental problems facing the Nation and the global community. The anticipation and prevention of environmental damage will continue to require that the ecological dimensions of a project, a policy, or a federal action be considered at the same time as the economic, social, and engineering considerations; however, the weight we give to environmental

consequences will increase. Proposed development or action will attempt first to avoid adverse impacts, then minimize or reduce them, and finally compensate for unavoidable effects over the life cycle of the project or action. Simply put, the environmental aspects of all we do must have equal standing among other aspects — not simply a “consideration,” but part of the “go-no-go” test along with economics and engineering.

President Bush has stated that we will protect and preserve wetlands and adopt a no net loss of wetlands policy. We will wholeheartedly support the President’s wetlands initiative (to the full extent of our authorizations) in our project planning, our operations and maintenance activities, our military programs, and our regulatory program. In doing this we will also strive to protect other precious natural resources, including valuable agricultural lands. While our current programs already provide essential protection for our water resources and wetlands, I am committed to strengthening them and using the regulatory program, within legal and policy bounds, to protect wetlands from unnecessary destruction or degradation.

In our military program, the land, water, and natural resources made available to the Army are limited and must be carefully managed to serve the Army’s short and long term needs. Embracing an environmental ethic and applying this ethic to our stewardship of our natural resources is vital and will be an important ingredient in supporting our Army. Environmental leadership and a commitment to go “beyond compliance” must be the standards upon which our service to the Army is measured.

Our work, military, civil, and support for others, depends on creative, environmentally sensitive engineering. We must look at our work in a broad social and environmental context, as well as in technical and economic terms. Decision makers (our higher authorities, project partners, and customers) need to be aware of the regional and life cycle consequences of each possible solution we recommend. We must plan wisely at the outset and

integrate environmental concepts with engineering creativity in all phases of our projects and activities. We will not only mitigate environmental impacts of development, but, when authorized to do so, we will expand our work that directly addresses environmental problems as a central purpose of the engineering effort. We will continue to consider both structural and non-structural solutions in solving problems and in protecting and restoring our environment. All of this will depend on our continuing to develop the requisite environmental engineering talent.

We have already realized the opportunities environmental engineering brings to the Corps. For example, we are investing nearly \$500 million annually in solving environmental problems in the area of hazardous and toxic waste. Restoration of contaminated sites is and will continue to be a significant environmental issue facing the DOD, EPA, DOE and other agencies. This challenge requires engineering capabilities that Army Engineers have demonstrated in EPA’s Superfund and the Defense Environmental Restoration Programs. Environmental engineering and supporting research and development account for nearly three quarters of a billion dollars of our FY ‘91 budget – military, civil, and support for others.

Among all agencies whose primary reason for being is not environmental protection, you have been leaders in integrating and embracing environmental values – with your continued efforts we will build on that leadership. It is especially important to forge new partnerships with the total environmental community and other resource agencies as well as with those who pursue development. We can learn much from one another, and I challenge you to engage in continuing dialogues among these diverse interests.

Thanks to the visionary, pioneering efforts of our predecessors, we have a good story to tell about the environmental value we have designed and built into many of our projects; the aggressive research and development we have conducted to

enhance the environmental aspects of our efforts; and the environmental protection achieved through our regulatory program. In more recent years, we have intensified our environmental focus in research and development, civil works, military, and support for others programs. Now, I believe our Nation asks more of us. Yes, we must continue the good work we have begun but we must also enhance the environmental aspects of our basic missions. We must be capable and willing to respond to new missions that feature solving environmental problems just as we have for navigation, flood control, military construction, etc.

I recognize that until we have included changes in the vast body of guidance that directs our actions, there may be a frustrating gap between our words and our deeds. For example, we will ex-

plore updating the principles and guidelines that are the basis for water resource project formulation. Bear with me in this transition.

Finally, I ask each member of the Corps to integrate environmental sensitivity into our day-to-day business. The cumulative consequences of our work must reflect a clear interest in protecting the quality of our environment and natural resources – we will be measured by what we do, not what we say. Our commitment must be to environmentally sustainable development in which we do not compromise the future while we meet current needs. Now is the time to use our engineering, scientific and management capacity to advance our Nation’s environmental goals. We recognize that sustaining the environment is a necessary part of building and securing this Nation.

BECOMING ENVIRONMENTAL ENGINEERS FOR THE NATION AND THE WORLD

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Introduction

Humanity is moving toward a new consciousness of Earth and nature. This consciousness has been stimulated by often confusing and bitter debates among the engineering and environmental communities. Unfortunately, such experience has left a stronger impression of adversarial rather than cooperative relationships. This impression is transitory and will change. Evolutionary biology now points to cooperation rather than to only self-interest as key to species survival and growth. Experimental game theorists (Axelrod) now show that truthful and cooperative relationships are most likely to produce best collective and individual benefits. Such is the theoretical back drop of modern Public Engineering.

At the bottom line, the public engineering community share interests with the environmental community that are far deeper than the adversarial positions they frequently defend. Public service engineers, the environmental community and the public(s), need credible governmental agents as instruments to achieve environmental goals. If government is viewed as incompetent, inefficient or untrustworthy, both the environmental community and the public engineers will suffer. In short, the environmental community and the engineers need one another. Credible government depends on its officials being open and honest with the public. It also means achieving stated goals. Achieving goals means applying science to situations in the best way we know—in other words, taking risks. That is engineering and that is how we will meet more of our environmental aspirations.

To reach environmental ends, the world needs engineering means. To employ engineering means requires justification in terms of environmental ends.

Current Trends, Situations and

One could cite many trends driving to the conclusion stated above. Here are a few.

Our existing institutions do not fit emerging environmental problems

While the major environmental problems (such as waste and toxic cleanup) are primarily engineering problems, the public programs for dealing with the problems are primarily run by scientists, administrators and lawyers. We are not using our national resources of Federal public service engineers wisely. We need to find a way to put these engineering resources to work on the most salient public engineering problems. On the one hand, we could say that new institutions must be created. On the other hand, we could adopt a philosophy that current institutions can be made to service emergent needs.

Our institutional means for achieving environmental quality are increasingly inappropriate to meet the needs of environmental and economic health

The National Science Foundation (1979) and the National Research Council (1986) show that the science of environmental impact analysis is deficient and should be upgraded. EIS's have

become the major instrument in raising environmental consciousness and in leveraging environmental concerns to the decision process. However, the Environmental Impact Statements (EIS) debates focus primarily on procedure and, to some degree, even inhibit substantive scientific concerns from being considered. Posturing and positioning dominates over discovery of substantive interests (Stakhiv, 1988). Recent Office of Technology Assessment (OTA) reports suggest that Environmental Protection Agency (EPA) contract management is inadequate and detrimental to achieving environmental means. The Department of Energy (DOE) is increasingly criticized for withholding public information about deficiencies in construction and operation of nuclear power plants. These are only a few examples of how new agencies and instrumentalities designed to deal with environmental health are themselves becoming dated.

Federal Spending in natural resources is increasingly dominated by environmental concerns

In 1965, Water Resources spending accounted for 61% of total Federal spending for natural resources and the environment. In 1988, it accounted for 27%. At the same time, pollution control and abatement has grown from less than 10% to roughly 33% of total Federal spending for natural resources and the environment. In other words, Federal concern for natural resources—a traditional concern of the civil engineer—is rapidly being defined in environmental terms.

Environmental health and environmental quality go beyond political and disciplinary boundaries

Solving environmental problems requires agreements among organizations and peoples under different political jurisdictions. This is a problem familiar to water resources professionals. It is one of the reasons the U.S. Army Corps of Engineers, years ago, organized around river basins. There is conflict in the way nature has organized versus,

man's political divisions. We have only to look at our inability to place NIMBY'S (Not-In-My-Backyard) such as waste sites. Apparently, our political institutions do not allow broad enough regional trade-off among NIMBY'S. We must either restructure our current institutions or find new and effective ways of negotiating among our current political jurisdictions to achieve solutions to difficult problems such as siting and waste clean-up.

We are increasingly mired in a psychology of constraints and limits

Numerous commentators have marveled at the recent history of strange alliance among economists and environmentalists, particularly in the water resources field. Both find shared interests in constraining and limiting traditional water resources development. While reacting to and stopping projects may have been useful to raise our consciousness, it is not sufficient to achieve environmental and economic health. While it is true that a good rule is often "when in doubt, do nothing," such a rule cannot be sustained forever. As long as we continue to make policy in the spirit of constraint and limit, we will increasingly be dominated by a fear of the future. We must overcome that fear and act to create, rather than react, to our future.

A changing nature of professionalism throughout society and Public Engineering

Something is happening throughout society. When presented with the statement "the government cannot be trusted to do what is right," 23 percent of the American public agreed in 1958. In 1980, 73 percent agreed! (Keiman, 1987) Something is happening! Much of the public holds bureaucrats and professionals in low esteem. Although one can say that Americans always criticize the government, it is more than that. Studies in the 1920s and 30s show much higher esteem for government institutions and bureaucrats.

Throughout society the very meaning of professionalism is changing. Patients no longer

say “cure me,” they participate with doctors in their own diagnosis and treatment. Clergy may no longer maintain strict distinctions between the “lay” and “religious” and may no longer consider themselves the sole salvation mediators between heaven and earth. Lawyers can no longer neglect avenues of alternative dispute resolution or avoid linking their individual actions to the overall state of social justice. Should engineers be surprised when “Joe Sixpack,” who uses a power plant feels a right in influencing its design or location?

Professionalism includes not only the final goods and services provided, but also the means employed to deliver those goods and services. The means by which the goods and services are delivered establish a relationship with public clients and/or customers.

Changing nature of administrative processes in the democratic state

Since the late 19th century, the United States has blended the separation of power doctrine with a distinction between administration and legislation. Agencies such as the Corps have come to recognize the blending as a distinction between technical versus political. Although this is theoretically plausible, the distinction rarely fits reality. Leaders have to publicly recognize that we operate in a gray area between technical and political. Our integrity and professionalism will be found in the way we explicitly blend, rather than separate, these issues.

Furthermore, the administering of laws has come to look more and more political. Legislatures seem to write legislation that is more general than specific. Judges shy away from substantive judicial review and review procedure. Thus technical agencies, such as the Corps, are placed in the position of distributing to the people benefits and costs of its programs. This is especially true in the environmental area. Who sacrifices what for the implementation of national policy comes to roost right on the doorstep of the Corps. Therefore, the

technical agency begins to look more and more like the distributor of political benefits than the implementor of narrow technical decisions. This will continue. Engineers must accept it and must adopt a leadership role in this area.

Tensions among political, management, and engineering visions of ethics are normal and often healthy. Much of the history of American civil engineering has been written around managing such tension. But the balance is fragile. It can easily tip, especially in times such as the last 10 years, when social values and public expectations are rapidly changing. At worst, the professional engineer begins to believe subconsciously, if not consciously, that politics is bad, irrational, and unethical. This is dangerous in a democratic society because the engineer retreats to a world of technical idealism. If that happens, professional existence can become either coping by incrementally conceding to evil or by constantly making valiant last stands for honesty and purity. Such feelings can fuel the mirror imaging of political and managerial supervisors.

Political managers’ cynicism is reaffirmed by the “narrow-mindedness” and arrogance of technical professionals. The political professional’s role becomes to either manipulate or just plain steamroll over an otherwise uncreative and inert mass of engineers. Therefore, we must find alternatives to both technical elitism and populist demagoguery.

Dilemmas Within The Environmental Community

While there seems to be much agreement on major environmental problems, there are some disconnects between public perceptions and environmental experts over the most salient and dangerous environmental problems. There is also increasing disconnect between the means to achieve environmental goals and the ideologies the environmental community often espouses.

For example, look at Sustainable Development. Sustainable development is rapidly becoming the byword among environmental communities. Making sustainable development a reality requires reconciliation between the environmental community's conservationist roots and its newer public safety and health spirit. At the turn of the century, T. R. Roosevelt, Pinchot and others catapulted conservation into high public policy visibility. However, conservatism was utilitarian in spirit. It sought to maximize beneficial use while minimizing resource costs in service of human quality of life.

The environmental movement born in the 1970s moved far more toward the spirit of setting absolute standards for health and safety as protection against impending crisis or apocalypse for addressing public policy. The utilitarian approach seeks to weigh good against bad for each action in a given situation. While the utilitarian uses the same principles across situations, the balancing might not always produce the same answer. The absolute approach seeks to discover the rules of law and set standards which must be met in all situations. The rigidity of this approach does buy certainty and one type of equity—that all are in some way treated alike. However, it also can bring obsessive legalism. Unfortunately, the utilitarian approach, as used in the resources field, with stylized and often narrow procedures, also looks rigid. Thus, the question becomes who defines what is the: good versus the bad or; benefit versus cost.

The environmental community is also struggling over how to move beyond negative-reactive to proactive-creative stances. The time has passed when access, visibility and credibility are derived from the shared experience of being negative. This movement from the pessimistic to more optimistic approach taps subconscious conflicts within the environmental movement.

Much of the motivational hooks used by the environmental community has been apocalyptic. That is, environmentalists have built on a guilt that

what we have done in the past has been wrong, or they have built on a vision of impending doom and gloom. Theologically, that seems like focussing on the fallen nature of man. However, the movement to become proactive focuses more on optimism, liberty and the freedom that man has to co-create the kind of future quality of life he chooses.

In this vein, much of the philosophical and more theological speculation within the environmental movement is looking toward ideas of creativity and the creation myths of humanity. This focus on creation and creativity has also led to a blending of feminist views of history with what we already know about the so-called left-brain/right-brain dichotomies in man. This dilemma is more than esoteric.

The tension between the creative-optimistic and the pessimistic-guilt philosophies within the environmental community will, in the short run, grow. At the bottom line it raises the practical question—"What is environmental success? What is it we want to create?"

The tension between the conservationist utilitarian spirit and the newer absolutist public health spirit creates some ethical dilemmas as well. For example, should the public policy posture of the environmentalist be policeman or participant? Is it ethical to establish unmeetable goals as standards for public action that have major distributional effects across social classes? Is such an approach recommended when we know that it will depreciate the value or even the legitimacy of the very government instrumentality asked to implement it? Is it ethical to use natural absolutes when we really know that nature, as a baseline, is itself change?

Indeed, there seems to be a general confusion within the environmental movement about man-nature relations. What is natural and what is man-generated? Nature is change, it is dynamic. While we seek no-net loss of wetlands, we know that non-man-generated, or "natural", causes exceed man-made causes of wetland loss. Nature's

destruction to nature, such as Mt. St. Helens, often vastly exceeds anything the most ambitious engineer could envision. Who issues God the permits for such action? In this confusion over the relationship of man and nature, some environmental ideologies begin to translate into a deep denial of progress. Man and ecosystem become a zero sum gain. Any gain for man is loss for the ecosystem. Indeed, the man-nature distinctions, either explicitly or implicitly used in environmental debate, often build on an unclear sense of status quo.

As environmental leaders critique the past and look to the future, the issue of purpose has become paramount. The question is how will we know if we are successful in our environmental efforts? Barry Commoner's (1988) critique of environmental progress is instructive. He shows how we have either reduced, eliminated, or failed to reduce or eliminate certain toxic elements in the air and our water. Yet, we are left with a sense of a series of battles but no sense of the war.

Now that the public is greatly concerned about our environmental health, we need to have a better sense of the overall "war." We must know what battles we could lose so that we somehow don't lose the war. Thus, Commoner calls on environmentalists to go beyond immediate issues and look to the means of production for solutions to environmental problems. This is a debate over the purpose or ends for which we humans strive.

The environmental community must be careful to avoid the syndrome that "to accept environmental ethics we must deny our past." Much of the environmental debate depends on the understanding of man as a historical actor. Humans must be seen in the context of their environment and situations as they see it at the time. Humans must act in the context of what their reason tells them about their surroundings.

In fact, this is what humans have done. We must understand that in the 1930s when we built dams we were acting out of the same spirit. We must be careful, to be more gentle with ourselves

and our past. The environmental community needs to learn how to call us to understand our interaction with the ecology today without criticizing our past to the point of forcing us to deny that past. To do so will alienate us from our history, a trend which some say is already occurring. But without a shared sense of history, a people cannot generate a sense of destiny. And, a sense of destiny is needed to achieve sustainable environment and build an ethic of stewardship. Engineers must learn from the past in light of what we know today. The message is not to deny or invalidate the 25 years experience of that engineer. Rather it is to channel that engineer's 25 years of experience in ways that help us meet needs as we understand them today.

Dilemmas in The Engineering World

If the Civil Engineer is going to achieve the ASCE's goal of: "delineating the role of civil engineering as the primary link between construction-related technology and society and stepping forward to lead in finding solutions to environmental and infrastructure deterioration, the public civil engineers will have to broaden their self-image beyond exclusive design-construction to program management."

Much of civil and water resources engineering has been viewed primarily as structural intervention into natural systems. Such interventions are justified for the best of reason—to minimize stress on the social system, and to create growth opportunities. While useful, this view can be dangerously limiting. Engineering can subtly become the application of one set of solutions to many problems. The problems then become defined more through a narrow understanding of possible technical solutions than through a broader understanding of social needs. Many engineers talk about the old days. Those were the days when civil engineers wore white hats, when civil engineers did great things for people—built dams, lit up valleys, and helped people rebuild from a depression. These same engineers are now often seen as problems or as wearing black hats.

One reason the white hats have become black is their “decalcification” of the profession. Engineers often define their profession as a finite set of solutions applicable to a wide range of problems, rather than as a capability for serving public needs or for creative problem solving.

Roots of such a mind set can be found in the history of Civil Engineering and engineering education. In the Civilized Engineer. Samuel Florman goes back to ancient Greece to find the historical roots of valuing science above practical knowledge. While science has clearly informed engineering, the U.S. engineering profession, built from craft guilds and frontier pragmatism, has often emphasized a less than elite industrial class mentality. But engineering is full of contradictions and must seek balance among these contradictions, such as practice versus theory; craftsmanship versus science, and military necessity and civic benefit (p.64) Therefore, Florman:

... pleads the cause of a humanistic professionalism of ennobled engineering that will rise out of the ashes of vocational training. (p.173)

In his book The Tower and the Bridge (1983), David Billington shows how engineering done in the context of economic efficiency and aesthetic constraints can be creative. He traces structural engineering in the U.S. and shows how it is really a new art form. Like Florman, he places art and creativity in the center of civil engineering.

“Civilization requires civic or city life and city life forms around civil works: for water, transportation, and shelter. The quality of the public city life depends therefore on the quality of such works as aqueducts, bridges, towers, terminals and meeting halls: their efficiency of design, their economy of construction and the visual appeal of their completed forms. At their best, these civil works function reliably, and cost the public as little as possible.”

In his classic address to the American Society of Civil Engineers in 1890, J.E. Watkins stated “the engineering profession typifies better than does any other the restless progressive

practical spirit which needs once again to be unleashed in service of environmental goals.” Our public engineers, the Corps of Engineers particularly, must move beyond seeing themselves as a set of solutions seeking application to problem solvers.

The environmental community, as it struggles with the concepts of creative versus reactive or preservation, is also touching a fundamental thread of the engineers’ tradition. The engineer, as creator, is an important part of the civil engineers’ history which has been forgotten. It is only in the late 19th century that the architect and engineer become distinguished in our own society. Historically, artist, architect and engineer were far more blended than we have come to view the profession in the 20th century.

We seem to have lost the idea of engineer as architect, artist and dreamer. Walking through the halls and offices at West Point, one is struck by numerous remarkable sketches and drawings done by now rather famous former cadets. Lacking photography and satellites, young engineer cadets were trained and evaluated as artists to increase their proficiency for surveying and mapping. What, today, so explicitly taps this artistic and creative spirit? In our dialogue with the environmental community, the creative will be brought back to the center of professional consciousness. Indeed, in thinking about the creative aspects of engineering, the engineer may rekindle some flames from his own past.

The assumption is often made, with some justification, that the engineer is a left-brain analytical as opposed to the right-brain nurturing person. But it is interesting that there is a great right-brain tradition in engineering which is built on a creative spirit, the same creative spirit which is driving and nurturing, creative and feminine, with which the environmental community has brought us in touch. So, the environmental engineer faces the exciting prospect of rediscovering part of his own tradition.

Who Is The Environmental Engineer? The Old Versus The New Engineer

To begin with, the environmental engineer is not simply a retread sanitary engineer. Clearly, our society certainly needs to elevate its concern about waste beyond a degrading garbage man picture if we are to do anything about hazardous and toxic waste. The “environmental engineer” of today is proactive, creative and seeks to bring environmental concerns into the design phase of engineering and thus create and mold new options. In defining a new environmental engineer, we must be careful not to deny the validity of our past, but to affirm a need for that past experience and to liberate that experience in service of our emergent new understanding of goals of health and development. So what is the difference between old and new environmental engineers? Let us look at three macro areas of difference.

Professional and Public Ethics

The 1970s brought environmental impact assessment, social impact assessment, and technology assessment. In the 1980s we have risk assessment. Should we be surprised that in a period of austerity, of shifts between environmental quality and economic development values, and of calls for growth, that managing uncertainty and assessing risk become important? After all, if we are to do the same or more with less, what are the risks? Who is going to take the risk, and to what extent? The assessment and the assignment of risk goes to the heart of what it means to be an engineer. It goes directly to the distinction often made between performance and design criteria.

A recent article in the *Washington Post*, “The Slippery Ethics of Engineering,” uncovers further complexity in the engineer’s ethical role. Taft Broome (1986) states that there are new ideas about what engineering means:

...engineering is always an experiment involving the public as human subjects. This new view suggest that engineering always oversteps the limits of science.

Decisions are always made with insufficient information. In this view, risks taken by people who depend on engineers are not really the risks over some error of scientific principle. More important and inevitable is the risk that the engineer, confronted with a totally novel technological problem, will incorrectly intuit which precedent that worked in the past can be successfully applied this time. ...Interestingly these new moral dimensions are not being created primarily by philosophers. They are the works of engineers themselves.

Broome further states:

Most engineers regard the public as insufficiently informed about engineering intuition—and lacking the will to become so informed—to assume responsibility for technology and partnership with engineers or anyone else. They are content to let the public delude itself into thinking that engineering is an exact science or loyal to the principles of conventional sciences (i.e., physics, chemistry)

Broome states that the practice of using intuition leads to conclusions put forth by others that engineering is an experiment involving the public as human subjects.

We are part in parcel of that environment for which we plan. When we start planning we interact with and change that environment for which we plan. Our engineering and planning themselves become change agents. Thus, we can subtly cross the line from scientific to self-fulfilling prophecy—or modern mythmakers!

At the bottom line we must move from a paternalistic to “informed-consent” view of professional ethics (Broome, Thompson 1987). We must bring people to the idea of choosing the level of risks rather than seeing themselves as passive recipients of risk. This informed consent model of professional ethics means we will become balancers and facilitators more than dictators of specific solutions. We must focus, not just on the acts, but our relationship to those who are acting.

Publicly, we must move from standards to guidelines or principles. In philosophical terms, this means moving from absolutist to utilitarian-

ism as the basis of policy making. As we have already noted, we should be moving to blending our public health absolute preservation and our conservativeutilitarian traditions. Accountability, performance and power sharing will become part of the public ethic we must foster. As engineers, we must move even further to blending and mixing quality and quantification in our approaches.

Self-Definition

Although design-construct is central to the new public service engineer, there is more. The new engineer must broaden the concept of engineering many have held in the last 50 years. The new engineer seeks to uncover shared values and interests underneath positions held by adversaries and create new alternatives based on those values and interests. For example, the water engineer already looks beyond just structural solutions to mixes of structural, natural and behavioral actions to solve problems.

We must move from seeing ourselves as a set of solutions seeking application, to seeing ourselves as problem-solving capacities. We must move from defining ourselves purely as engineer constructors or designers to engineer managers and stewards. We must move from defining ourselves as manipulating things to managing systems, people and life. We must come to see our milieu not as machines, but as growing, interdependent biological entities.

We must move from a mechanistic view to a biological paradigm

At least since the first space photographs of Earth, we have been moving away from the Newtonian enlightenment image of the universe as a clock or mechanism, to the universe as a biological entity that grows, decays, evolves, transforms and lives. No longer can we see man as separate from

nature. Indeed, even the most apparently inert matter is, in some way, organic and living. Modern physics has changed our most basic scientific images of subject-objective distinctions.

We must build to grow. We must move from a domination idea to a nurturing idea. We must move from being observer of events around us to an understanding that we are, inevitably, participants in those events. We must view our actions in the long as well as the short term and we must decide on actions in terms of how we think the world should be.

Conclusion

Throughout our Nation and the world, environmental consciousness has been raised. Now, public service engineering, management, design, and even construction is needed to meet those environmental goals we are setting. In the U.S., we must realign our public institutions to achieve a better balance between public service engineering capacity and environmental needs throughout the nation. As we move to seek a better balance, debate within the environmental, engineering and development communities will intensify. However, as the rallying cry of sustainable development is showing, these debates will lead to greater understanding of shared interests and values among these communities. The major philosophical meeting ground will be the emergent realization of our need to create new alternatives and to proactively create the future we seek to mold.

The only way to reach the ends of sustainable development is with the means of engineering skill. Now is the time to place the power of this Nation's public engineering capacity in service of environmental goals and to consciously choose and create our future.

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EDUCATING ENVIRONMENTAL ENGINEERS FOR THE 21ST CENTURY

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For more than twenty years, engineering educators have been receiving advice on changes in the undergraduate civil engineering curriculum. The advice has been proffered in forms ranging from modest suggestions to strident demands. It can be found in publications ranging from professional journals to reports prepared by national commissions. The advisors range from concerned critics to distinguished presidential advisors.

However, the entrenched educators, for reasons that only they can explain, have largely ignored almost everything suggested or proposed. They have stonewalled, equivocated, jawboned, haggled, quarreled, quibbled and resisted in every way imaginable all but the most modest changes.

Examine the civil engineering curriculum of the late 1960s or early 1970s at an engineering school of your own choosing. Compare it to the civil engineering curriculum of the same school today. It is unlikely that you will find any significant change. There might be a course or two more in the humanities and social sciences than there were twenty years ago. Also, a course in either oral or written communication might have been added. Finally, you might find a “capstone” design course today that wasn’t there when we first began welcoming the returning Vietnam veterans. Most surprising of all, in many cases you will find that the number of credits required to complete the baccalaureate degree is actually less now than it was when man first walked upon the surface of the moon.

Now, think for a minute about how the world has changed in those twenty years. Think about what we know now that we didn’t know then.

Perhaps more important, think about what we now know we don’t know that we thought we knew then. Isn’t it unconscionable that the basic education we provide young people entering the civil engineering profession today is so little different from what it was twenty years ago?

Nowhere within the field of civil engineering has the need for change been more obvious than in the environmental engineering specialty. And nowhere else have the demands for change been more insistent. Admittedly, some changes have occurred. The course we once called “Sanitary Engineering” has been relabelled “Environmental Engineering,” and it now includes discussion of air pollution and hazardous waste disposal in addition to water pollution and solid waste disposal. That’s clearly a step in the right direction, but only a tiny step. It doesn’t begin to address the larger problems faced by today’s practicing environmental engineer, and it is wholly inadequate to meet the needs of the environmental engineer of the 21st century.

Like other specialty areas, knowledge in the field of environmental engineering can be subdivided into the following broad categories: philosophy, policy, processes and problem-solving approaches. To see where changes in current environmental engineering practices are needed, let us examine each of these in turn.

Philosophy in any area of subject matter knowledge deals with the great ideas and ideals of the subject. Understanding of the philosophy underlying a given subject is fundamental for successful endeavors in that area. To understand the philosophy in a given subject matter area, one must be

exposed to writers and thinkers who have explored ideas and shaped the beliefs, ethics and thinking of those who are knowledgeable in the area. Reading, writing, and thinking about the work of people like Rachel Carson, Barry Commoner, Rene Dubos, Donella and Dennis Meadows and others like them is essential for engineers who want to understand the ideas that underlie the way other educated people think about the environment. The study of relevant philosophy is one of the weakest parts of undergraduate engineering education in all specialty areas, but in no other area is it as debilitating as it is in the field of environmental engineering. Other professionals with far less understanding of effective problem-solving approaches often have a far greater understanding of the fundamental environmental issues and concerns than engineers have.

Policy is the vehicle through which philosophy is transformed into action. Policy evolves from and is based upon an understanding of philosophy, but it is shaped by history, heritage and politics. Environmental engineering is probably ahead of most other specialty areas in engineering in that most environmental engineering courses include at least a cursory review of relevant national legislation in the various areas of practice. The unfortunate circumstance is that where such information is provided, it is almost always limited to a description of the legislation insofar as it pertains to problem-solving approaches. There is very little discussion of the conditions and circumstances that produced the legislation; almost no understanding of why a particular set of standards or practices is mandated and why other equally plausible, and perhaps superior, approaches are ignored; and virtually nothing about how successive legislative acts and policies in a given field are related to one another and to other acts and policies in other related areas. Without this knowledge the engineer is severely handicapped in understanding why a particular problem-solving approach is employed.

Process leads one from policy to problem solving. In environmental engineering, process includes things such as planning, public involvement, social and environmental impact assessment, economic

and financial feasibility evaluations, elections and referenda, and budgeting and financing projects. Some of these subjects are mentioned in passing, but few get any significant treatment in today's civil engineering curriculum. Even as basic a process as planning, which underlies every civil engineering project of any size, is given such cursory treatment in civil engineering curricula that there is today no well-known textbook on civil engineering planning. Where texts dealing with planning topics do exist, they are likely to be in the area of environmental engineering or one of its closely related subdisciplines. However, they tend to focus more on techniques than on concepts, and they rarely provide the kind of information about philosophy and policy that is needed to develop real understanding of the rationale for the planning process.

Problem solving is, of course, the one area in which the civil engineering curriculum is strong. For environmental problem solving, the civil engineering curriculum undoubtedly provides a greater exposure to information concerning state-of-the-art approaches than any other course of study. The civil engineering graduate is generally well-equipped to understand and employ proven solutions to common environmental problems. Unfortunately, without the knowledge of philosophy, policy and process that is needed to underpin their problem-solving abilities, civil engineers are increasingly being relegated to a role somewhat akin to that of a super technician. For a profession that has prided itself on conceiving, designing, and constructing great projects, that's a bitter pill to swallow.

Some might argue that the primary mission of engineering education is to produce problem solvers. Therefore, they would argue, focusing our educational efforts on problem solving is altogether fitting and proper. Given the explosion of scientific and engineering knowledge in the last forty years, they say, what is needed is more attention to problem solving, more emphasis on scientific theories and principles, more practice in deriving, developing and employing analytical techniques.

After all, they argue, few others working in the environmental area have either the interest or the inclination toward problem solving that the civil engineer possesses. And that argument is a compelling one. It is an argument that cannot be ignored, for without problem-solving ability efforts to understand philosophy, policy and process become academic exercises that contribute little to man's prospects for living in harmony with the natural environment.

The argument, then, is not that we should reduce educational efforts directed toward continuation and enhancement of the environmental engineer's expertise as a problem solver. Rather, we should precede and combine those efforts with studies of environmental philosophies, policies and processes. Some would argue that these latter educational efforts are most properly the dominion of those engaged in supplying the humanities and social science components of an engineering education. In most schools, if we rely on those courses and teachers as a source of knowledge for the things engineers need to know about environmental philosophy, policy and processes, we will be sorely disappointed. Those teachers believe (and it is difficult to dispute their belief) that the limited opportunities which exist in engineering curricula for exposing engineering students to humanities and social sciences need to be devoted to broader human concerns than those which would be addressed if these courses were restricted to discussions of environmental and engineering issues. Furthermore, in many schools the teachers of these courses are not themselves prepared to do what needs to be done for the environmental engineering student.

If this teaching is to find its way into the environmental engineering curriculum, the proper place is probably within the context of existing courses. The best teachers are probably the existing teachers of these courses. The material that needs to be learned is material that already exists. It is not necessary to wait for it to be developed. Best of all, much of it can be learned outside of the classroom and laboratory through reading and writing assignments that are carried out on the student's

time rather than on the instructor's. Consequently, inclusion of this type of learning does not necessarily mean that other types of subject matter will have to be deleted from existing courses. That's not to say that there won't have to be some adjustments in the amount of student effort devoted to learning how to solve problems as opposed to why a particular solution approach is necessary or desirable (unless one assumes that there is infinite elasticity in students' time allocations!).

Ideally, one would hope that teachers would see fit to emphasize and reinforce student reading and writing assignments with classroom discussions and laboratory activities that expand the student's understanding and appreciation of the relevance of philosophy, policy and process to problem solving. Much of the best writing on these matters, by its very nature and because of the frame of reference of its authors, is not very explicit on the relationships among issues, ethics, processes and real-world problem solving. Many students are not intellectually mature enough to fathom these relationships on their own, given the nature of the existing materials. For these reasons, engineering teachers who want their students to understand the importance of this knowledge will have to develop teaching strategies that communicate the notion that these assignments, although different from most typical engineering assignments, are not simply "busywork," but vital and integral elements of learning the body of knowledge essential to environmental problem solving.

Although some engineering teachers might be uncomfortable with assignments that explore philosophical, ethical, social, economic and political dimensions of problems such as acid rain, deforestation of tropical rain forests, global climate change and hazardous waste disposal, an appreciation for the scope and complexity of these dimensions is fundamental knowledge for those who would hope to produce impenetrable solutions. Engineers who cannot understand these dimensions are crippled, and they are unlikely to be able to act in a truly professional capacity as problem solvers in the

21st century.

In conclusion, improving the education of environmental engineers for the 21st century is not primarily a matter of more and better laboratories (although they are probably needed), or a matter of more and better courses (although the education would undoubtedly be improved by adding courses—probably through the addition of a fifth year to the undergraduate curriculum or by recognition of the master’s degree as the entry-level credential), or a matter of more and better teachers

(although we all recognize the need to continue to improve our teaching abilities). We can achieve significant improvements in educating environmental engineers by merely recognizing and emphasizing within the context of our existing environmental engineering coursework the importance of reading, writing and thinking about the philosophical and ethical bases for environmental issues confronting society and about the policies and processes that support and prescribe our efforts to solve environmental problems.