TO: D Chery
From: Stephen Parker
3/16/89

NATIONAL RESEARCH COUNCIL
WATER SCIENCE AND TECHNOLOGY BOARD
MINUTES
SIXTEENTH MEETING--AUGUST 18-19, 1988
NAS/BECKMAN STUDY CENTER
100 ACADEMY DRIVE
IRVINE, CALIFORNIA

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ATTENDANCE

Board Members

Michael Kavanaugh, Chairman
Stephen Burges
James Heaney
R. Keith Higginson
Luna B. Leopold
G. Richard Marzolf
Robert R. Meglen
James W. Mercer
Betty H. Olson
P. Suresh Chandra Rao
Gordon Robeck
Dan Tarlock
James R. Wallis

Absent

Richard A. Conway
Howard Kunreuther
Patricia Rosenfield

WSTB Staff

Stephen D. Parker
Sheila D. David
Chris Elfring
Wendy L. Melgin
Jeanne Aquilino

Liaison Representatives and Guests

Clifford Barrett, U.S. Bureau of Reclamation
Norman H. Brooks, CalTech (CETS Member)
Daniel B. Curll, Boston Harbor Associates
Jonathan French, Camp, Dresser, & McKee (Boston)
James R. Hanchey, U.S. Corps of Engineers
Thomas J. McGill, Naval Weapons Center, China Lake, California
Marshall E. Moss, U.S.G.S.
Edgar Nelson, Soil Conservation Service
Brent Paul, U.S. Bureau of Reclamation
William Roper, U.S. Corps of Engineers
Michael Stoner, Naval Weapons Center, China Lake, California
David Wegner, U.S. Bureau of Reclamation

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August 18, Thursday

CALL TO ORDER

Chairman Michael Kavanaugh convened in executive session the sixteenth meeting of the NRC's Water Science and Technology Board at 8:45 a.m. on August 18 at the NAS Beckman Study Center, Irvine, California.

ON POTENTIAL SOURCES OF BIAS

Following the call to order and introductions, Kavanaugh and S. Parker, facilitated a discussion of members' potential sources of biases. (Such a discussion is required annually of NRC committees and, with several WSTB members present for their first meeting, this provided also a good opportunity for getting better acquainted.) Each member provided a brief report on his/her professional history, areas of research, and public positions taken on issues of relevance to the WSTB program. It was concluded that no member had biases that would at all reduce the objectivity or effectiveness of the WSTB.

AGENDA

The proposed meeting agenda was then reviewed and adopted.

MINUTES

The minutes of the Board's fifteenth meeting, March 17-18, 1988 in Chicago were approved with no changes.

FUTURE MEETING SCHEDULE

Up-coming WSTB meetings are scheduled as follows:

(1) 17th Meeting; December 12-13, 1988; Washington, D.C.

(2) 18th Meeting; April 20-21, 1989; Washington, D.C. (combined with colloquium)

(3) 19th Meeting; September 14-15, 1989; Woods Hole, Massachusetts (NAS Study Center)

OVERVIEW OF WSTB AND NRC

Primarily for the benefit of the five new members present, Parker provided an overview of the WSTB, its history, and its place in the overall structure of the NAS/NRC. He talked about some of the Board's highlights, important reports, the matter of bi-commission oversight, audiences, and impacts of

reports, and funding arrangements and levels in support of the WSTB and its committees.

COMMENTS ON FUTURE DIRECTIONS

Michael Kavanaugh, a WSTB member for three-years and recently (July 1, 1988) appointed chairman, talked briefly about the fundamental role of the Board and some of his personal goals for future activities. He commented that "water quality technology" was an area of the program without much history and a likely important future. Assessments of research-needs, activities that translate into public policy, and issues of education of water resources professionals are areas of potentially great benefit. Also, he felt the program might be developed better with respect to "interfaces" (such as coastlines and estuaries) and the "intermedia" (soil/water/air). Kavanaugh then opened the floor to a lively discussion of future directions, desirable types of activities, and the various reasons why those that seek advice from the WSTB do so. This set the stage nicely for later, scheduled discussions of new initiatives.

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At 10:40 a.m., the executive session ended, and the meeting was opened to several agency liaison representatives and guests (see p. 1).

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REVIEW OF EXISTING PROGRAM

Irrigation-Induced Water Quality Problems. Chris Elfring reviewed the background, purpose, goals, work style, and products of this committee. She reported on recent membership changes and noted that the current cooperative agreement had been extended through March 1990. She provided an overview of the committee's report now in draft and summarized plans for the future (e.g. more of a committee focus on national problems, more attention to science and technology). Members expressed considerable interest in the report in progress--it is a technology/policy document with conclusions drawn from the San Joaquin experience and should receive a good deal of attention upon release. Every effort will be made to promote its broad distribution.

The WSTB was asked to provide guidance regarding committee participation or co-sponsorship in a national conference involving the University of California, SJVDP, and others (background on the proposal was contained in agenda book). The Board disapproved sponsorship of this activity, principally on the basis that the committee would be lending its name to the activity while having little control over it. Further the Board did not like the forcing function role of the somewhat, incompletely peer-reviewed activity. The committee should participate in some way, but no sponsorship. It was noted that the general area of agriculture and environmental quality would make a good, future colloquium topic.

Coastal Erosion Zone Management. Sheila David summarized the activities of this study committee. The committee understands its task clearly, has a solid work plan, and is making good progress. It was agreed that Howard Kunreuther would be invited to serve in an "ex officio" capacity to this committee. Also, it was agreed that committee chairman William Wood would be invited to attend and report at the December 1988 WSTB meeting.

Evaluation of USGS National Water Quality Assessment Pilot Program. David reported that this committee was formed and a study schedule developed. Jim Heaney will be representing the WSTB and Ken Potter the Committee on USGS Water Resources Research as "ex officio" representatives to the study committee. Some discussion followed during which it was concluded that it was unfortunate that the NAWQA effort has not yet well integrated the Hydrologic Benchmark and NASQAN (national water quality monitoring networks) programs.

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LUNCH 12:15 TO 1:15 P.M.

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Committee on USGS Water Resources Research. Betty Olson (committee chair) summarized the activities of this committee. Its various activities had evolved considerably since its first year when focus had been almost exclusively on the "institutes and grants programs." This broadening of focus, it was agreed, needed to be reflected in a new cooperative agreement, scheduled to be put in place in April 1989, and the membership balance should continue to reflect the changed scope (both extramural and intramural water research activities of the USGS, as well as other developing programs of scientific interest). S. Parker would work together with Olson and Kavanaugh on revising the updated scope of work. Parker had asked for an assessment of membership needs and comments on particular individuals (for a membership rotation due to occur January 1, 1989). The members had several specific suggestions and some general concerns. Particularly, the WSTB felt the committee had too strong a representation from academic homebases, too few women, and needed additional expertise in chemistry. L. Leopold commented that he felt this committee must pay closer attention to research projects and also the process of managing the agency's large in-house research program. He expressed specific concerns about productivity, peer review, researcher age distribution, and others. Parker responded that some of these process-related factors were high on the committee's list of concerns and that he was working with Marshall Moss to structure the committee's future agenda to consider better the process aspects of the National Research Program.

Glen Canyon Environmental Studies. Dick Marzolf, chairman of the study committee, discussed the history of the project and provided an overview of two reports produced by the committee. Dave Wegner, Glen Canyon Environmental Studies Program manager, described in some detail the DOI/BuRec response to the

various recommendations of the committee. At the urging of L. Leopold, the Board agreed to back strongly and try to help cause implementation of the recommendations of this committee. One recommendation in particular, the retaining of a senior outside scientific advisor Leopold felt was critical. The work of this committee is scheduled to terminate in March 1989 and there was discussion about the desire to continue on, in a broader role. This was generally seen as desirable, however any initiative of this type was deferred until after the next (late October) meeting of the committee, when it should be clear what DOI had done with the two sets of recommendations already transmitted.

Opportunities in the Hydrologic Sciences. Steve Burges and Wendy Melgin described the accomplishments of this committee (chaired by Peter S. Eagleson) in its initial eight months. The study, among other things, is hoped to put hydrology on a stronger scientific footing. The large interdisciplinary study committee is building its report around a core chapter of "frontiers" in the science. Eventually the committee will try to recommend priorities and assess educational programs in hydrologic sciences. Though this study has been part of the Board's program for well over a year, some concerns were expressed about the study's genesis and the usefulness of its results because of its focus on scientific hydrology. Parker reviewed the project history and commented that such "disciplinary reviews" were not uncommon projects for Boards of the NRC. He noted that the report might in fact be of little immediate interest to today's practitioner, but he expected that the committee had enough appreciation for emerging problems so that their recommendations for research would eventually lead to improvements in applications, 10 years in the future approximately. He noted that the committee was aware of concerns about its work by the broader hydrologic community and consequently was making some outreach efforts. Parker was enthusiastic about prospects for a successful final report, based on progress to date. It was agreed that Peter Eagleson should be invited to the next (December 12-13) WSTB meeting. Parker thought this would occur at a potentially useful time in the study schedule. He thought it would be appropriate also, as Eagleson had recently been appointed to the Commission on Physical Sciences, Mathematics, and Resources--one of the Board's two parent commissions.

Ground Water Modeling Assessment. W. Melgin, Jim Mercer, and Suresh Rao provided comments about progress of this study committee (chaired by Frank Schwartz). The committee's report is nearing completion and is being written to a common format. No serious, substantive problems are foreseen, but the report may be completed a month or two behind schedule.

## INTRODUCTION TO BOSTON REGIONAL WASTEWATER MANAGEMENT ISSUE

S. Parker and Norman Brooks explained that there had been discussions among some Academy members (Brooks, Donald Harleman, Abel Wolman) and with entities in the Boston area about the NRC undertaking some type of assessment of options for wastewater management. There, the debate is heated concerning

the value of an EPA-mandated secondary treatment plant to be constructed at a cost of several billions of dollars in the late-1990's. Some believe that primary treatment and attention to other problems (e.g. combined sewer overflows) might accomplish more at lower cost. Brooks' noted the Clean Water Act was quite strict on secondary treatment for urban coastal areas and that Section 301(h) of the Federal Water Pollution Control Act is a vehicle for waivers. No significant waiver has ever been granted, however, a fact not necessarily consistent with good science, engineering, economics, and public policy. This suggested to him a study of possibly considerable benefit. (Note this introduction was presented in preparation for the August 19 discussions with D. Curll and J. French).

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After a brief recess at 4:45 p.m., the Board and guests enjoyed a reception, dinner, and presentation "The Range of Light" by James Long.

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## August 19, Friday

### BOSTON REGIONAL WASTEWATER MANAGEMENT ISSUE (continued)

The meeting reconvened at 8:40 a.m. on Friday, August 19. Mr. Dan Curll (President, Boston Harbor Associates) and Dr. Jonathan French (Camp, Dresser, & McKee and Boston Society of Civil Engineers) were welcomed formally to the meeting. They had come to discuss the possibility of WSTB involvement in the Boston Harbor issue and presented background information and described current status of related activities in Boston. They feel that EPA's regulatory order will cause a great sum of money to be spent on secondary wastewater treatment while not leaving any money to deal with the very serious problem of combined sewer overflows. After considerable discussion, the Board concluded that, for a variety of reasons it would not be appropriate for the NRC to focus on the specific regulatory issue confronting Boston, but that the illuminating discussion did point up an important broader policy issue that should be considered. The question of scope of involvement was deferred to the new initiatives planning session scheduled later in the day.

### WATER RESOURCES EVALUATION OF INDIAN WELLS VALLEY (CHINA LAKE, CA)

The Board was joined by Thomas McGill and Michael Stoner from the Naval Weapons Facility, China Lake, CA. They have responsibility for base public works, including water supply and came to the meeting to discuss a possible role for the Board in resolving the question of ground water supply availability in the Indian Wells Valley. The valley is in an isolated desert and home to the Navy, industry, and agriculture. There is great concern over the valley's future because of the question of availability of ground water to accommodate growth. The question boils down to whether the valley is a "closed" or "open" geologic basin. There are two schools of thought and the

WSTB was seen as a credible, outside "neutralizing force." After discussion, it was agreed that there was no appropriate role for the WSTB. The services of USGS or perhaps a consulting firm were more in order, but the Board did offer to help to the extent it could in informally guiding McGill and Stoner to establish contacts with the Survey or consulting firms.

COLLOQUIUM PROGRAM

S. David reported progress on the Board's March 1988 colloquium on Great Lakes levels. The report was progressing well and soon a review draft would be completed. S. Burges and Pat Rosenfield were identified to review the report on the Board's behalf. David then discussed the upcoming (March 1988) colloquium on ground water remediation. She invited suggestions of attendees; some suggestions as well as other comments were given. Also after a short discussion it was agreed that the project should be retitled "Remediation of Ground Water Contamination: Are Science and Technology Compatible?"

Following these reports a more general discussion on the colloquia occurred. While these Board-sponsored activities have been successful, interesting, and have produced popular reports, they have consumed tremendous resources and were threatening to become routine and burdensome. Alternative types of activities were suggested, such as small retreats or planning sessions (Leopold and Higginson) and a distinguished lecture series (Parker). It was agreed that these ideas had enough merit that 2 to 3 hours should be scheduled at the December meeting to discuss breaking the rhythm of the colloquium series with such other activities. In fact it appeared that enough members would be willing to present lectures to book several meetings. (Note: a possible initial presenter/topic was identified--J. Wallis on Use of Geographic Information Systems in Water Resources.)

NEW ACTIVITIES

Restoration of Aquatic Systems: Science, Technology, and Public Policy. S. David reviewed developments with respect to this project, including a planning session where the study proposal had been developed. It was agreed that the proposal included a proper scope of work and, with a few minor changes, was approved by the Board. With clearance at the NRC Governing Board on September 14, the proposal would then be transmitted to a number of organizations that had indicated preliminary commitment to the project. Several individuals were suggested for committee membership and a nominating committee of J. Heaney, L. Leopold, R. Marzolf, and S. David was identified.

Options for Western Water Management Change--Third Party Effects. S. Parker reported that the prospects for funding of this joint project with the Board on Agriculture were excellent. Ford Foundation would reportedly process our proposal after October 1, and prospects with the federal agencies were also good. After some discussion nominations were requested; several dozen were received. J. Heaney, K. Higginson, D. Tarlock, and S. Parker were identified as the membership nominations committee.

Preparation for Water Supply Emergencies. At the urging of members (March meeting), John Boland and Parker had met with representatives from the FEMA, EPA, and Corps of Engineers to discuss the Board's interest in undertaking a study of the preparation for water supply emergencies. This meeting had not been successful, as those agency representatives present saw little need for such an activity. The Board encouraged Parker to be in touch with the AWWA Research Foundation to determine their interest as perhaps the federal role is being fulfilled.

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LUNCH 11:45 A.M. TO 1:15 P.M.

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NEW INITIATIVES PLANNING SESSION

Following a discussion on future directions and potential new activities for the Board, attendees divided into four groups for some substantive debates and identification of specific topics. Following about two hours, the meeting reconvened for group reports on various recommended topics for future study. These are summarized on the following pages. It is the intent to attempt to develop appropriate scopes of work and identify sponsorship for each in the months ahead. (Note: indicated in parenthesis are the individuals who provided draft descriptions to aid in preparation of minutes.) The topics are:

Wastewater Management for Urban Coastal Areas
(M. Kavanaugh and S. Parker)

It is proposed to undertake an assessment of options for wastewater management for urban coastal areas. The study purpose would be to help improve the scientific and technological bases, environmental effectiveness, and economic efficiency of policies pertinent to ocean and estuarine coastal wastewater management.

At present the Federal Clean Water Act requires coastal communities to provide full secondary treatment of sanitary wastewaters and prohibits ocean disposal of sludge, a bi-product of treatment. Though, Section 301(h) of the Federal Water Pollution Control Act Amendments of 1977 can provide for a waiver of this required level of treatment, no significant waivers have ever been granted by the U.S. EPA, as EPA evaluations have judged primary treatment as not capable of achieving ocean water quality goals. The cost of providing secondary treatment is great and, at the same time, federal grants for construction of wastewater treatment plants are in the process of being phased out.

Experiences with disposal of municipal sewage effluents and sludges have demonstrated that the coastal ocean has, in fact, considerable capacity to assimilate wastes and the suitable combinations of source control, primary

treatment, and outfalls with diffusers can provide for disposal with minimum of environmental risk. Such experiences suggest that flexibility in interpretation and enforcement of current laws might be justified on scientific, technological, and economic bases.

The considerable future national investment in the coastal area wastewater management infrastructure must be governed by a more flexible, scientifically-based set of policies than are now in place. Such policies must: be reflective of costs and benefits, integrate consideration for other media (i.e. land, air, inland water bodies), and be flexible enough to account for regional conditions and new information. As a practical matter, evaluation of "Section 301(h)" and options for its decision framework are identified as the most effective WSTB study approach. To this end, the Board proposes a two-year/$250,000 study, carried out by a specially appointed committee of experts that would:

(1) review regulatory requirements pertinent to sewage discharge in marine waters,

(2) assess in general water quality problems faced by urban coastal areas,

(3) generally assess technologies and remedial acts that can address these problems,

(4) consider several case studies in the context of technology and policy options, and

(5) provide generic recommendations to urban coastal communities on procedures for selecting among available actions to improve coastal water quality.

A study of the type suggested would be useful to regulators at the state and federal levels, the courts, and the public. Whether because they have failed to modernize their sewage systems, identified new pollution problems or outgrown the capacity of their current systems, coastal urban centers around the country face the same need to match wastewater management technologies with available funds and set priorities. The U.S. EPA should have sufficient interest to sponsor such a study; if not other sponsors, primarily at the state and local levels, can be identified.

## Water Quality Criteria for Special Populations
(B. Olson)

The age structure of the American population is rapidly changing. The number of individuals over the age of 65 is increasing at a rate of one million per year in the United States. It is well known that as the age of individuals increases, the relative ability of the immune system to ward off infectious agents decreases. The leading cause of admissions to hospitals from nursing homes is infection. Advances in chemotherapy, organ transplants and treatment

of immune deficiency disease are creating an ever burgeoning population that is susceptible to many disease producing agents. Thus, a significant proportion of the population, over 10 percent, is becoming increasingly susceptible to bacterial agents commonly isolated from our water supplies. The public health significance of commonly occurring organisms to these agents is unknown. However, evidence primarily from Legionelloisis diagnosis at autopsy suggests that water may be a vehicle for infection to these groups. The questions are should this growing group of individuals be protected from these organisms through water treatment by water suppliers, special home treatment, etc. and whose responsibility is it to inform them of the potential risk? Currently, there is no information available to these groups as to the inherent health risk of drinking or bathing in distributed water.

## Supplemental Irrigation
(D. Tarlock)

Supplemental irrigation is increasing in humid and semi-humid areas. The technology is easy, but these areas have a minimal institutional framework--compared to the arid West--to manage irrigation. A study of the scale of supplemental irrigation and the stresses that it poses for existing resources, primarily ground water, and the possible management options would be useful.

## Greenhouse Effect: Criteria for Impact Determination
(B. Paul)

While there is growing acknowledgement that the mechanisms are in place that will bring about significant warming of the earth's surface, there is little agreement as to the specific effects--particularly relating to local geographic areas. In fact, it could be years before some of these effects become defined even in broad regional terms. In the meantime decisions concerning the development and operation of water resources in the 10 to 40 year time frame must continue to be made. The Bureau of Reclamation, for example, is continually renegotiating long-term water contracts as the original 40 year agreement matures. In addition, studies are being considered to see if some of these older projects could be redefined to better reflect today's needs and values. The alternatives that must be evaluated must reflect the potential impacts from the greenhouse gasses. Since it is impossible to project the localized effects of global climate change other means must be developed to help anticipate the range of impacts.

A set of criteria, hopefully a simple set, should be developed that relates the parameters of temperature and rainfall to the impacts on a given river basin or project area. By identifying a set of characteristics which can be measured and/or observed and which relate the physical and economic condition of the basin to long term changes in temperature and rainfall, a measure of vulnerability to various levels of climate change can be developed. With this measure will be able to determine those areas which are especially sensitive to climate change and in which future activities should be avoided or in which measures must be considered early to minimize the impacts of change.

With this knowledge planners and operators of water systems will be able to prioritize areas and allocate limited resources to take reasonable steps to avoid or minimize the effects of climate change even before solid specific data is available.

Land Water Interfaces/Potable Water/Public Health
(to be provided by R. Marzolf)

Instream Water Use Needs
(to be provided by L. Leopold)

Emerging Technologies in Water Treatment
(M. Kavanaugh)

Water treatment, in its broadest interpretation, includes potable water treatment, municipal and industrial wastewater treatment, removal of hazardous constituents from contaminated ground water, industrial water treatment, and treatment of wastewater streams with low concentrations of suspended solids (< 10 percent). In the context of increasingly stringent environmental standards or criteria, and a societal goal of reducing intermedia transfers, new demands are being imposed on water treatment technologies.

This committee would evaluate the current status of water treatment technology in the US, identify future requirements of water treatment technologies (efficiency, reliability, cost-effectiveness, ability to minimize residuals), evaluate the adequacy of technological development in this sector (historically and currently) and assess the need and recommend strategies for achieving these perceived future requirements.

Specific questions that could be addressed include the following:

(1) Has the development of water treatment technologies in the U.S. kept pace with the requirements for meeting environmental goals?

(2) How does the U.S. development of these technologies compare to developments in other countries? (e.g. France, West Germany, Switzerland, Japan).

(3) Assuming that advances in water treatment technology are needed, is the current U.S. model for such development adequate for the task?

(4) Are investments in research needed by industry, by federal or state governments, or by trade associations?

(5) Would closer cooperation between universities and industry provide for more rapid development of new technologies?

(6) What other constraints inhibit U.S. technological development in this sector? Lack of technically trained personnel? Foreign competition? Inadequate federal support? Inadequate investment by users of water treatment technologies?

Potential funding sources include the following: EPA, DOD, API, EPRI, Edison Electric Institute, other industry associations, American Water Works Association Research Foundation.

## Water Conservation (Reuse)

Withdrawn by G. Robeck. Subject area well covered/little opportunity for further WSTB contributions, according to Robeck.

## Techniques for Assessing Ground Water Vulnerability
(S. Rao)

In evaluating the contamination of soil, surface waters, and ground waters, two possible approaches exist. In a reactive mode, various monitoring programs--at various spatial and temporal scales--can form the basis for identifying problem areas that have become "contaminated." Reconnaissance surveys (such as NASQAN, NAWQA, EPA's National Pesticides Survey, etc.) provide a basis for regulatory actions to remedy contaminated sites and to locate the sources (nonpoint or point sources) of this contamination. This also provides a basis for various land-use management decisions. The second approach, in a proactive mode, is to identify the land areas or activities that lead to contamination. Regulatory and management options can be implemented to prevent soil and ground water contamination. It is the latter approach which is the focus of the suggested initiative.

A number of techniques have been developed to assess the potential for contamination (i.e., vulnerability) either at a local scale (e.g., specific site and activity) or at a regional scale (e.g., state- and nation-wide pesticide-use policy). Use of simulation models and various empirical numerical rating techniques have been proposed for evaluating ground water vulnerability. For example, USEPA-OPP uses a numerical ranking scheme, DRASTIC, to assess the contamination potential on the basis of physiographic and hydrogeologic setting of land areas. Similar DRASTIC-like Delphi rating schemes are being developed and used by several state environmental agencies for regulation of pesticide use. Simulation models of varying complexity (e.g., PRZM, GLEAMS ...) are being used to assist OPP and other agencies in making decisions on pesticide registration. The relative merits of models vs. rating schemes have been debated in the literature and by EPA's SAC in deciding registration of Aldicarb pesticide use. Aldicarb case is seen as a template for all future decisions made by OPP on pesticide registration. In nonagricultural applications, the questions of site-selection for land

treatment or land disposal sites for hazardous wastes also require an assessment of relative vulnerability of various candidate sites.

The use of Geographic Information Systems (GIS) is becoming popular for inventorying, archiving, retrieving, and displaying spatial data needed in the above stated approaches for evaluating vulnerability. GIS coupling to numerical rating schemes and to simulation models enables producing computer-generated thematic maps displaying contamination potentials or vulnerability of land areas (at county-level or higher spatial scales). However, the varying levels of data quality and scales of the spatial data bases supporting GIS, introduces great uncertainty in the reliability of these vulnerability maps. Questions as to how to validate the predictions (i.e., the GIS thematic maps) through sampling or monitoring also need to be resolved.

The proposed initiative will examine the scientific basis for and the relative merits or limitations of various schemes for evaluating vulnerability of soils, surface waters, and ground waters. Recommendations will be made on the appropriateness of the schemes within the regulatory framework. Technical issues on data quality and uncertainty of vulnerability assessments will also be addressed.

## Water Resources Education
(J. Mercer)

Enrollment in college science and engineering departments is decreasing. We need to raise students' level of awareness of water science and engineering by providing educational assistance to grades K through 12. Distributing educational literature to teachers and encouraging water professionals to interact with grades K through 12 by providing talks, participating in career day, and providing summer job opportunities are some of the ways to reach this goal.

Possible funding for this effort includes private foundations or professional societies such as AWWA. One other possibility is Water and Man (contact Ed Dalton, Energy and Man's Environment in Salt Lake City). This last contact was suggested by Keith Higginson.

## The GIS/Hydrology Interface: The Present and the Future
(J. Wallis)

A Geographic Information and Database System (GIS/D) is a computer hardware and software system designed to collect, manage, analyze, and display spatially referenced data, and integrate it with other database information. GIS/D technology is spreading rapidly throughout the hydrologic and water related fields on a worldwide basis. This rate of spread can be expected to accelerate in the years to come as increasing populations, coupled with growing political sensitivity to "quality of life issues" result in new laws that stress orderly, integrated planning between all layers of government. Technological changes can be expected to hasten the spread of GIS/D development and use.

A video presentation showing applications of GIS and the utility of GIS and coupled mapping display capabilities as well as a commentary of trends and applications to water resources will be given to the WSTB members.

## Climatic Change Effects on Hydrologic Forecasting
(K. Higginson)

Hydrologic data are used to plan and operate projects for the use of water resources. Long-term records of climate, streamflow, ground water levels and other variables are used to predict future water resource conditions and needs. It is assumed that the record of the past may reasonably be expected to be repeated in the future.

More recently, concern has been expressed over "the greenhouse effect" or "El Nino" or other phenomena to explain variability in climatic conditions and water supplies. Scientists who study long-term climatic indicators may not be in agreement over whether current climate, streamflow and ground water levels represent "wet" or "dry" cycle conditions. The drought which has affected much of the nation in 1988 brought an awareness of water supplies during such period compared to more "normal" conditions. Questions are being asked as to how to plan for the future. Was 1988 an unusually dry year or is it the normal condition which may be expected to continue for some time in the future?

This study would review the science of hydrologic forecasting as the basis for planning and operation of water resource development projects.

This study could be supported by the National Weather Service, Federal Emergency Management Agency, Corps of Engineers, Bureau of Reclamation, and Soil Conservation Service. It is possible that it might also be of interest to several foundations. Funding in the range of $200,000 over a two-year period is anticipated.

## Estimating the Impact of Anthropocentric Climate Change Upon Water Resources
(J. Wallis and S. Burges)

Meteorologists and climatologists cannot provide deterministic estimates of the expected changes in environmental fluxes (radiant energy, precipitation, wind fields) at the catchment scale of typical water resource projects, or across projects separated by distances on the order of a few hundred kilometers. There are four fundamental questions concerning climate change impacts:

(1) What statistical techniques can be used to identify change, given short time series of highly variable and correlated phenomena?

(2) What techniques can be used to estimate trends reliably?

(3) Can trends be represented better as deterministic processes or as stochastic processes (e.g. stationary fractals)?

(4) What are the magnitudes of likely impacts on water resources, irrigated agriculture, and urban water supplies of any such changes in fluxes?

Possible funding sources: USBR, EPRI, EPA, FEMA, U.S. Army Corps of Engineers.

ADJOURNMENT

The meeting adjourned at approximately 3:00 p.m.