

WATERSHED MANAGEMENT

PLANNING FOR THE 21ST CENTURY

Proceedings of the Symposium sponsored by the Watershed Management Committee of the Water Resources Engineering Division, American Society of Civil Engineers, in conjunction with ASCE's First International Conference on Water Resources Engineering in San Antonio, Texas.

in cooperation with
American Society of Agricultural Engineers
U.S.D.I. Bureau of Reclamation
Society of Range Management
Society of American Foresters
U.S.D.A. Natural Resources Conservation Service
Soil and Water Conservation Society
National Council of the Paper Industry
for Air and Stream Improvement, Inc.
U.S. Environmental Protection Agency

**San Antonio, Texas
August 14-16, 1995**

Edited by Tim J. Ward



Published by the
American Society of Civil Engineers
345 East 47th Street
New York, New York 10017-2398

stabling
currently
ed, but
and
most

tershed.
s, which
l strate-
ng
ge
s.
hanced
s and
nd land
is
be of

e Plan,

nd
ssion.

Ad-

d
ressure

f the

A HISTORICAL PERSPECTIVE OF
ASCE'S APPROACH TO WATERSHED MANAGEMENT

Kenneth G. Renard, F. ASCE
Richard H. Hawkins, M. ASCE

Abstract

The activities of ASCE's Watershed Management Committee since its inception in 1964 are summarized. The Committee has arranged seven Symposia with ASCE-published proceedings at five year intervals. It has also sponsored two Task Committees which published reports in the Journal of Irrigation and Drainage Engineering. The Symposia, Task Groups, and the general history of watershed management during the period are discussed. Some comments are offered on the future of watershed management and the Committee activities.

Introduction

The American Society of Civil Engineers, Irrigation and Drainage Engineering Division (now the Water Resources Engineering Division) has been active in watershed management since 1964 when a technical committee was formed.

Although there was a predecessor Task Group on Watershed Management (begun in about 1960 and headed by Leonard Schiff), the present committee began in 1964. The Committee Chair and affiliation are given in Table 1. It is rather obvious that Timothy J. Ward deserves credit for continuing service to the committee activities. His dedication has done much for ASCE membership and the affiliated organizations that have cosponsored the watershed management symposia for over 30 years. It is also rather obvious that much of the committee membership has come from agencies within the U.S. Dept. of Agriculture, Universities, Consulting Engineering firms. Finally, much of the committee membership has come from the Western U.S.

Res. Hydr. Engr., USDA-ARS Southwest Watershed Res. Center,
Tucson, AZ 85719 and Prof. University of Arizona, School of
Renewable Natural Resources. Biosciences East. Tucson, AZ, 85721

ASCE's Watershed Management activities began in the early 1960's following the creation of Departments of Watershed Management at Colorado State University and the University of Arizona. Similar programs at Oregon State University and Utah State University followed shortly thereafter. Although these sprang from forestry origins (and some work continued in Forestry departments), they drew heavily on and incorporated much from associated engineering and hydrology programs. Also, there existed a heritage of watershed management interest via programs in Soil and Water Conservation, usually housed in Agricultural Engineering academic programs. There was an emerging interest in watershed management for water supply enhancement throughout the western U.S. about that time. Thus the sequence of Watershed Management Symposia

Table 1. ASCE's Watershed Management Committee Chairs.

<u>Name</u>	<u>Organization</u>	<u>Location</u>	<u>Year</u>
Leonard Schiff	USDA-Agric.Res.Serv.	Fresno, CA	1964
Jack F. Hannaford	Sierra Hydro. Consult.	Placerville, CA	1965
Jack F. Hannaford	Sierra Hydro. Consult.	Placerville, CA	1966
George N. Newhall	USDA-Forest Service	San Francisco	1967
Elmo W. Huffman	Calif.Dept. Water Res.	Sacramento, CA	1968
Glen L. Martin	Montana State Univ.	Bozeman, MT	1969
Glen L. Martin	Montana State Univ.	Bozeman, MT	1970
Richard H. Hawkins	Utah State Univ.	Logan, UT	1971
Richard H. Hawkins	Utah State Univ.	Logan, UT	1972
Eugene F. Serr	Calif. Dept. Water Res.	Red Bluff, CA	1973
E. Bruce Jones	MW Bittinger & Assoc.	Ft. Collins, CO	1974
Robert T. Joyce	Tenn. Valley Authority	Knoxville, TN	1975
Kenneth G. Renard	USDA-Ag. Res. Service	Tucson, AZ	1976
Douglas W. Barr	Barr Engineering	Denver, CO	1977
Charles F. Leaf	Leaf Engr. & Assoc.	Sterling, CO	1978
Roger P. Betson	Tenn. Valley Authority	Knoxville, TN	1979
Clifton W. Johnson	USDA-Ag. Res. Service	Boise, ID	1980
Edward R. Burroughs	USDA-Forest Service	Moscow, ID	1981
Robert E. Rallison	USDA-Soil Cons. Service	Washington, DC	1982
Timothy J. Ward	New Mexico State Univ.	Las Cruces, NM	1983
Timothy J. Ward	New Mexico State Univ.	Las Cruces, NM	1984
E. Bruce Jones	Resource Consultants Inc	Ft. Collins, CO	1985
Paul A. Rechard	Western Water Consultant	Laramie, WY	1986
Paul A. Rechard	Western Water Consultant	Laramie, WY	1987
Ranvir Singh	USDI-Office Surface Mine	Denver, CO	1988
Robert E. Riggins	U.S.Army, CERL	Urbana, IL	1989
Frederick J. Watts	Univ. of Idaho	Moscow, ID	1990
Larry M. Younkin	Bucknell Univ.	Lewisburg, PA	1991
Vicente L. Lopes	Univ. of Arizona	Tucson, AZ	1992
Vicente L. Lopes	Univ. of Arizona	Tucson, AZ	1993
Timothy J. Ward	New Mexico State Univ.	Las Cruces, NM	1994
Timothy J. Ward	New Mexico State Univ.	Las Cruces, NM	1995

he early 1960's
d Management at
rizona. Similar
e University
ng from forestry
rtments), they
ated engineering
ritage of
l and Water
neering academic
shed management
rn U.S. about
ment Symposia

were an extension of that academic thrust and the recognized need for development of conjunctive surface/ground water resource development for the rapid expansion of irrigation. This need has continued to be a strong focus throughout the seven symposia (including the current) that have been convened.

Another major impetus for engineering-related watershed management interest in the 1950's and 60's was in PL 566, a USDA small (<250,000 acre) watershed program that used engineering structures, land use planning, and land management for flood control and enhanced local benefits. Much of the Committee membership during this time was allied with this program.

The creation of the Water Resources Research Centers in each state in the mid 1960's also complimented the interest in Watershed Management. These centers funded with money from the Department of Interior's Geological Survey emphasized the need for water management and a research capability within each state.

The Watershed Management committee was one of ASCE's vanguards in the increased environmental awareness in the 70's. In our view, ASCE was in a period of professional isolationism in the 50's and 60's, and the Watershed Management issue contributed to the kinder, gentler, and more ecumenical attitudes seen today.

There have been parallel watershed management activities in other professional societies. For example, the Society of American Foresters had such a committee in the 1950's that has since become their Forest Hydrology Committee. The American Water Resources Association now has a Watershed Hydrology Working Group. This group in AWRA held its own Watershed Management Symposium in 1972 in Fort Collins, CO. The Society for Range Management has a Watershed and Riparian Committee. In September 1965, the National Science Foundation Advanced Science Seminar was held at Penn State University, an International symposium on Forest Hydrology. The 813 page proceedings was Edited by William E. Sopper and Howard W. Lull and represents a major contribution (Sopper and Lull, 1965) to the field of watershed management. In any event, ASCE was the uniting force for this array as evidenced by the special sessions arranged by these affiliated organizations at the Watershed Management Symposia in Logan, UT in 1975 and in Boise, ID in 1980. This direction has slackened some since.

The Watershed Management Committee purpose listed in the 1964 Official ASCE Register was "to study the work under way in the field of watershed management; and to recommend and promote activities in this field which are of special concern to civil engineers". This statement continued until the 1972 Official Register when it was changed to state "to evaluate, in an engineering context, the relationship of land conditions to: (1) Sedimentation and erosion, (2) Water quality, (3) Water yield, (4) Floods, (5) Low flows, (6) Hydrologic processes, and (7)

<u>Location</u>	<u>Year</u>
San Francisco, CA	1964
San Francisco, CA	1965
San Francisco, CA	1966
San Francisco, CA	1967
Logan, UT	1968
Logan, UT	1969
Logan, UT	1970
Logan, UT	1971
Logan, UT	1972
Bluff, CA	1973
Collins, CO	1974
Collins, CO	1975
Logan, UT	1976
Logan, UT	1977
Logan, UT	1978
Logan, UT	1979
Boise, ID	1980
Boise, ID	1981
Logan, UT	1982
Cruces, NM	1983
Cruces, NM	1984
Collins, CO	1985
Logan, UT	1986
Logan, UT	1987
Logan, UT	1988
Logan, UT	1989
Logan, UT	1990
Logan, UT	1991
Logan, UT	1992
Logan, UT	1993
Cruces, NM	1994
Cruces, NM	1995

Processing hydrologic data using current technology, including remote sensing and computer sciences". This purpose continues even today although the purpose statement probably needs revision.

Definitions of "Watershed Management". Numerous groups and sources for the definition of watershed management are available in the literature. Hewlett (1982) admonishes "Consider the wise words of Voltaire: 'If you would converse with me, first define your terms as study and understanding begins with good definitions'."

In addition to the ASCE committee definitions, Boughton (1970) listed "Man's activities change and alter the rates and amounts of [water, sediment, salt, and pollution...from catchment areas]. The study of processes involved and application of current knowledge is generally called 'watershed management' in the United States."

The California Department of Water Resources (1964) defined watershed management as "The art and science of managing the land, vegetation, and water resources of a drainage basin for the control of the quality, quantity, and timing of water, and for the purposes of enhancing and preserving human welfare." Jeffrey (1968) and Wilm et al. (1957) state "The management of land for optimum production of water of a quality suitable for use, with due attention being given to soil stability and other products of the land" as a definition of watershed management. Brooks et al. (1991) state "Watershed Management is the process of guiding and organizing land and other resources use on a watershed to provide desired goods and services without affecting adversely soil and water resources." The Society of American Foresters (1944) states "the management of the natural resources of a drainage basin primarily for the production and protection of water supplies and water based resources, including the control of erosion and floods, and the protection of esthetic values associated with water." The University of Arizona (1991) states watershed management is the study of "...natural resources with an emphasis on the sustained production of commodities and amenities derived from wildland ecosystems, combined with a special awareness of water." Black and Eschner (1990) state watershed management is "...the planned manipulation of one or more of the factors of the environment of a natural drainage so as to effect a desired change in or maintain a desired condition of the water resource." All of these definitions center around the interaction between land use condition and hydrology, with accent on surface water and "small" watersheds.

The highlights of the ASCE committee activities have consisted of Symposia held at five year intervals since 1965 and a proceeding for each as detailed in Table 2. The first such symposia was convened in Billings, Montana in 1965. The same committee sponsored similar symposia in 1970 in Bozeman, MT, in 1975 in

Logan, UT, in 1980 in Boise, ID, in 1985 in Denver, CO, in 1990 in Durango, CO and now, the symposia in San Antonio, TX in 1995. Both Dr. Hawkins and I have been involved in these symposia since 1970. Thus, our comments are predicated on having been involved in most of the symposia. Table 1 shows some of the salient features of these meetings and proceedings

Table 2. Proceedings details of past Watershed Management Symposia sponsored by ASCE.

<u>Year</u>	<u>Location</u>	<u>Symposia Title</u>	<u>Number of Papers</u>	<u>Pages</u>
1965	Billings, MT	Development of the Total Watershed	25	410
1970	Bozeman, MT	Interdisciplinary Aspects of Watershed Management	28	411
1975	Logan, UT	Watershed Management: Research to Application	62	781
1980	Boise, ID	Symposium on Watershed Management 1980	110	1100
1985	Denver, CO	Watershed Management in the Eighties	44	319
1990	Durango, CO	Watershed Planning and Analysis in Action	61	596
1995	San Antonio, TX	Watershed Management: Planning for the 21st Century	50	???

Numerous other professional societies and government agencies have added their support (at varying levels) to the symposia over the years. They include:

- Professional Organizations
- American Geophysical Union
- American Society of Agricultural Engineers
- American Water Resources Association
- Society of American Foresters
- Society for Range Management
- Soil Science Society of America
- Soil and Water Conservation Society
- University Council on Water Resources

Government Agencies and Universities
 California Department of Water Resources
 Illinois State Water Survey
 Montana State University
 Utah State University
 U.S. Army Corps of Engineers
 U.S.D.A. Agricultural Research Service
 U.S.D.A. Forest Service
 U.S.D.A. Soil Conservation Service (Currently Natural Resources
 Conservation Service)

Symposia Details

The October 6-9, 1965 Watershed Management Symposium was held in Billings, Montana as a part of the Irrigation and Drainage Division Specialty Conference. The Watershed Management Symposium proceedings in this conference in contrast to those since that time, were included as an integral part of the Specialty Conference. Thus, 14 of the 25 papers in the proceedings dealt with the subject of Watershed Management. The conference proceedings do not reflect either a Chair nor an Editor so it is possible that the emphasis cited in Table 1 was less organized than subsequent conferences where the theme was directed to the Symposia. Papers dealing with watersheds included such presentation as: "Interest of the State in Total Watershed Development" (by Albert J. Dolcini); "Place and Role of the Civil Engineer in Total Watershed Development and Management" (two papers authored by Harvey O. Banks & Elmo W. Huffman); "Watershed Management: Effects on Basin Development" (by George N. Newhall and James L. Smith); "Recreation Impacts on Watershed Resource Development" (by Walter S. Hopkins); "The Effects of Urbanization Upon Development of a Watershed" (by H. C. Enderlin); "Research Guidelines to Sound Watershed Development" (by Roland R. Renne); "Flood Control and Its Effect Upon Development of the Total Watershed" (by J. O. Ackerman); "Impacts of Salinity Problems Upon Development of the Total Watershed" (by H.L. Parkinson & H.R. McDonald); "Public Law 566 and Its Effects Upon a Watershed in an Irrigated Area" (by John J. Walker); "Watershed Hydrology Research--Reynolds Creek Experimental Watershed" (by W. Russell Hamon & Clifton W. Johnson); "Water Yields and Stream Flows from Mountain Watersheds" (by John A. Adams); "Hydrologic Characteristics of Soil Types" (by H.N. Holtan, C.B. England & D.E. Whelan); and "Inter-American Center for the Integral Development of Water and Land Resources" (by Vaughn E. Hansen). The diversity of subjects covered at that time are generally applicable today even though 30 years have elapsed.

The August 3-6, 1970 Watershed Management Symposium was held at Montana State University in Bozeman and was chaired by Glen L. Martin who also served as editor of the proceedings. This was the first time that the symposia was a stand-alone conference although the Irrigation & Drainage Division Specialty Conference was held the same week.

The symposium topics were presented under the headings of (1) Water Quantity, (2) Water Quality, (3) Flood and Erosion Management, (4) Vegetation Management, and (5) Wildlife and Recreation Management. Panel discussions by the speakers in each session prompted lively discussions among the 150+ participants in the single track program format. The session chairs made introductory comments that summarized the key points for the materials in their session and provided an excellent starting point for the state-of-the-art knowledge of the discipline subject. The statements and collection of papers indicate the necessity for a multidisciplinary approach for total watershed management. For example, the water quantity session included presentations on water harvesting, evaporation suppression, snowpack evaporesublimation, the role of soils on water yield, and the importance of geology/geomorphology on watershed management. It is interesting to speculate how a similar session today might differ from the state-of-the-art presentations in 1970.

The August 11-13, 1975 Watershed Management Symposium was held in Logan, UT prior to the Irrigation and Drainage Division Specialty Conference. The Symposium was chaired by Richard H. Hawkins with assistance from committee members Robert T. Joyce and Kenneth G. Renard. A plenary session opened the symposium consisting of presentations on "Water Harvesting: State-of-the-Art" by K.R. Cooley, A.R. Dedrick, and G.W. Frasier; "Nutrient Release From Forest Harvest" by Earl Stone, a "Keynote Address" by Warren A. Hall; and "Non-Point and Diffused Water Sources: A Variable Source Area Problem" by John D. Hewlett and Charles A. Troendle. These papers prompted lively discussions and set the stage for the remainder of the symposium discussions.

Specific session topics grouped the papers as follows: Mining and the Watershed; Diffuse Pollution Sources; two sessions titled Applications and Techniques; Beneficial and Detrimental Effects of Livestock Grazing on Runoff and Erosion; Snow and the Watershed; Sedimentation; Vegetation Management for Water Yield; Infiltration Topics; Ground Water; Social, Political, and Economic Aspects; and finally Modeling and Simulation. The large attendance and participation by those in attendance were a highlight of this Symposium.

The July 21-23, 1980 Watershed Management Symposium was held in Boise, ID. Co-Chairs Clifton W. Johnson and Richard H. Hawkins with assistance from Roger P. Betson and Edward R. Burroughs, Jr. are credited with an outstanding Symposium and Proceedings that was so extensive that the papers were collected in two volumes. The four concurrent track format was predicated by the large number of invited and volunteered papers.

Session topics included the following: Erosion on the Watershed; Nonpoint Salinity Control; Vegetative Reclamation; Groundwater Management; Erosion and Sediment Models; Roads and Fires;

Turbidity and Soil Moisture; Snow on the Watershed; Sediment and Erosion; Modeling Land Use Changes; Water Quality; Rangelands; Mining Effects; Forest Watershed Management; Spatial Variability, Range Watershed Management; Phosphate Mining; Mining Models/Curve Numbers; Agricultural Watersheds; and General Watershed Management. The presentations, grouped under what might be considered a broad collection of titles like in other symposia in the series reflect the diversity of the backgrounds of people interested and involved in watershed management.

The April 30 to May 1, 1985 Watershed Management Symposium was held in Denver, CO in connection with the Annual Convention of ASCE. The proceedings were edited by E. Bruce Jones (Symposium Chair) and Timothy J. Ward. A plenary session which opened the Symposium consisted of presentations by Charles F. Leaf (Watershed Management in 1985), Martin M. Fogel (International and Educational Aspects of Watershed Management), and Albert Rango (A Look to the Future in Watershed Management). These presentations set the stage for the entire conference.

Presentations during the Symposium were grouped in the following themes: Applied Watershed Management; Watershed Modeling and Simulation; Watershed Management and Land Stability; Water Quality; and Watershed Hydrology. Like earlier and subsequent symposia, a wide variety of topics were discussed as well as material reflecting ongoing and completed investigations and research. The single track meeting format has not been repeated in any of the other symposia sponsored by the ASCE Watershed Management Committee.

The July 9-11, 1990 Watershed Management Symposium was held in Durango, CO prior to the Irrigation & Drainage Division Specialty Conference. The symposium was chaired by Robert E. Riggins who served as Editor with help from E. Bruce Jones, Ranvir Singh and Paul A. Rechar. Wayne N. Marchant, USBR opened the symposium with an invited presentation "Water Resources: How Do We Slice the Pie?" The thought provoking discussion of water supply and conflicts for this limited resource in water short areas was well received.

The symposium was organized along three concurrent tracks which highlighted the following topics: Precipitation and Climate; Rainfall-Runoff Response; Remote Sensing and Data Collection; Snow Hydrology; Water Erosion Processes; Geographic Information Systems; Effects and Control of Water; Sediment Yield and Transport; Role of Vegetation; Role of Soils; Regulatory and Economic Issues; Task Committee Reports (a synopsis of two ASCE Committee reports on (a) Water Use by Naturally Occurring Vegetation and (b) Evaluation Criteria for Watershed Models); Watershed Planning; Watershed Management: Case Studies; Water Use; In-Stream Flows; and Hydrologic Models and Evaluation. The paper collection (including a poster session) reflected the

widely differing interests of attendees from those with research interests to those involved in planning, design, and evaluation.

SYMPOSIA SUMMARY COMMENTS

The six previously published symposia give an interesting overview and perspective. The topics reflect the ebb and flow of public and scientific interests in watershed management and hydrology, as well as the associated land and water management. Throughout there has been a steady patter of papers on the traditional mysteries of watershed hydrology: Range impacts, infiltration, soil hydrology, water yield modeling, erosion, sediment movement, spatially distributed processes, fire effects, snow management, land stability, and the on-the-ground tools and methodologies of watershed management. There was "background noise" in urban hydrology and river basin management, enhanced by local watershed management experiences and case histories.

Perhaps the most interesting observation is the rise and fall (and sometimes) acceptance of trendy lines into the familiar, the relegation of some items into historical curiosity, and the evolution of new lines.

Some highlights illustrate this: The 1970 Bozeman Symposium carried an invited program in water quality--a new awareness at the time--and topics such as pesticides (Joe Caro), water temperature (George W. Brown), bacteria (Sam Kunkle), and forest clear-cutting effects (Gene Likens). The current high identification of water quality with suspended sediment and turbidity was not yet evident.

The 1975 Logan Symposium carried sessions specifically dedicated to the glamour topic of "modeling and simulation", a matter now taken as routine. Memorable plenary presentations--at least to those who were there--included Earl Stone's presentation on Nutrients Following Forest Harvest and John Hewlett's discourse on Variable Source Area Hydrology.

The 80's contain a wealth of expression on best management practices (BMP's) and on non-point source concerns, with a blip of interest on mining impact at the '75, '80, and '85 meetings, and non-point salinity at the '75 and '80 meetings. The decade of the 80's functioned as a transition into the 90's, for the symposia contained a wide variety of topics found in the earlier programs, as well as a lead-in to the 1990 symposia and the present gathering.

The 1980 Boise symposia dwelt on a wide spectrum of topics, but included the then trendy items of non-point salinity, mining effects and reclamation, turbidity, and snow. In 1985 - in keeping with the overall public mood - we saw movement towards management and planning and away from much of the defined detail

and technical topics seen earlier.

1990 is too recent in history to allow us good perspective. Our view from here is that it continued the trends set in the 80's toward the increased operational use of a watershed approach in planning and management, with much of the earlier technical concerns tucked away, though certainly not all solved. Decision methodologies also began to surface.

A number of watershed management topics seem to have come, peaked, and left our collective consciousness, though they have not necessarily gone away. With no order of importance or assumed complete coverage, these include the following.

- Hubbard Brook effect - nutrient release following forest harvest
- Salinity - nonpoint sources and the Colorado River problem
- Turbidity/sediment relations
- Water yield increases
- Physical models
- Water harvesting
- Snowpack management
- Weather modification
- Hydrophobic soils
- USLE and Curve Numbers

Some topics that have become commonplace, accepted, or even operational since the 1965 Symposia include:

- Computer modeling
- Water quality
- Land stability
- Non-point sources and BMPs
- Green-Ampt infiltration/rainfall excess
- Kinematic waves

Some topics currently trendy, with the destination yet to be resolved:

- Geographic information systems and remote sensing
- Climate change
- Riparian, channel, and wetland issues
- Decision support systems
- Chaos applications and risk analysis
- Assessing erosion and sedimentation with models such as WEPP

Other ASCE Watershed Management Activities

Besides arranging special sessions at the annual Irrigation & Drainage Division Specialty Conferences, the Watershed Management Committee has had several Task Committees with special assignments. In 1982, a Task Committee on Quantifying Land Use Change Effects was formed jointly with the Surface Water

Committee. The Committee Chair, Roger P. Betson, used a large number of people to "...determine the magnitude of the impacts to surface water systems that can be expected from major land use changes and to write a position paper based upon the findings."

The basic approach used to obtain information was through a questionnaire requesting information about hydrologic models capable of use without prior calibration. The models were to be capable of predicting the effects of land-use change upon one or more components of the hydrologic cycle. Components considered included flooding, water yield, low flow, sedimentation and water quality. From this questionnaire, the 28 models considered, and comments about them were summarized in the Journal article "Task Committee on Quantifying Land-Use Change Effects" (1985). Considerable discussion was presented on model confidence which was identified as coming from three sources: (1) Confidence based upon personal and technical knowledge; (2) surrogate confidence arising from full awareness of reduced model expectations; and (3) confidence based on faith in authority. Therefore, the task of assessing the confidence that might be placed in simulations obtained from complex [and simple] models becomes intellectually demanding since it requires the user to be sufficiently familiar with the model's components to be sure that all of the model output is reasonable. Dawdy (1987) and the late Ray Linsley (1987) presented thought provoking discussions of this paper pointing out some limitations of models to assess watershed management alternatives. Betson (1987) closed the discussions by pointing out that "...there is a need to recognize that models are employed in a variety of situations". It is highly unlikely that any model developer will state that his/her model does not do an excellent job of describing the data available.

In 1989, the Watershed Management Committee created a Task Committee on Definition of Criteria for Evaluation of Watershed Models with Charles F. Leaf as Chair. The Task Committee was to "...define the issues, review the literature on watershed models, and, ultimately define criteria which can be used to evaluate models; to plan and develop a treatise or monograph of evaluation procedures and develop a symposium or at least a session at a conference on the subject."

The Task Committee report (1993) addressed the problem practicing engineers face as they try to evaluate the usefulness of watershed models for solving engineering problems. Also addressed was the need for more complete parameter descriptions, unrealistic data needs, documentation, testing, and the lack of uniform criteria for evaluating a model's performance. Finally, recommendations for using some basic statistical measures to describe the performance of the models which are reported in technical literature.

The committee recommended that in addition to graphical plots, three simple evaluation criteria for continuous-hydrograph

ive. Our
he 80's
roach in
ical
Decision

me,
hey have
or

est

oblem

even

to be

as WEPP

ation &
Management

Land Use
ar

modeling and four for single-event modeling be used. Examples were prepared that show how combinations of these criteria can be applied for continuous snowmelt runoff and single-event, rainfall-runoff hydrographs.

Future Watershed Management Activities

Although it is somewhat dangerous to "crystal ball the future", some things are rather obvious. For example, the current down-sizing in public supported activities in the USA will be expected to have some implications, most of which will be expected to reduce support for such activities. It is also rather obvious that managers will have a continuing need for the technology associated with watershed management. The next ASCE Watershed Management Symposium should probably emphasize the international aspects of the topic.

New analytic techniques such as decision support, remote sensing, climate change, and efforts to increase water supply in more arid areas (and much of the earth's area consists of water deficient areas), riparian issues, remote sensing, "user friendly analytic models" capable of assessing man's influence in a watershed, and evaluation of watershed management (quantity, quality, and flood control) activities as we continue to attempt to modify the hydrologic cycle will create challenges not anticipated heretofore.

Finally, watershed management mixes physical, biological, and management-political forces under a single rubric. Such diversity is being increasingly recognized as the approach of choice to otherwise difficult management problems, e.g., nonpoint source management. This suggests the need for increased inter-professional cooperation and understanding.

References

- American Society of Civil Engineers. 1990 (and other years). Official Register. New York, N.Y.
- Black, P.E. 1990. Watershed Hydrology. Prentice-Hall, Englewoods Cliffs, N.J. 07632. 408 pgs. [Definition is found on p.xvii with joint credit attributed to A.R. Eschner]
- Boughton, W.C. 1970. Catchment Management in Australia-A Review. Civil Eng. Trans. of the Inst. of Engrs., Australia. 141-147.
- Betson, R.P. 1987. Closure of: Evaluation of Hydrologic Models to Quantify Major Land-Use Change Effects. ASCE, J. Irrig. & Drainage Engr. 113(3):435
- Brooks, K.N., P.F. Folliott, H.M. Gregerson, and J.L. Thames. 1991. Hydrology and the Management of Watersheds. Iowa State University Press 392 pp.

California Department of Water Resources. 1964. Watershed Management in the Eel River Basin. Bulletin 136, Appendix A, North Coastal Area Investigation, 141 pp. Calif. Dept. Water Resources, Sacramento, CA.

Dawdy, D.R. 1987. Discussion of: Evaluation of Hydrologic Models to Quantify Major Land-Use Change Effects. ASCE, J. Irrig. & Drainage Engr. 113(3):432-434.

Jeffrey, W.W. 1968. Watershed Management Problems in British Columbia: A First Appraisal. Water Resources Bull. 4(3):58-70.

Linsley, R.K. 1987. Discussion of: Evaluation of Hydrologic Models to Quantify Major Land-Use Change Effects. ASCE, J. Irrig. & Drainage Engr. 113(3):434-435.

Task Committee on Quantifying Land-Use Change Effects. 1985. Evaluation of Hydrologic Models Used to Quantify Major Land-Use Change Effects. ASCE, J. Irrig. & Drain. Engr., 111(1):1-17.

Task Committee on Definition of Criteria for Evaluation of Watershed Models. 1993. Criteria for Evaluation of Watershed Models. ASCE, J. Irrig. & Drain. Engr. 119(3):429-442.

Society of American Foresters. 1944. Forest Terminology. Washington, D.C.

Sopper, W.E. and H.W. Lull (editors). 1965. International Symposium on Forest Hydrology. Pergamon Press. 813 pgs.

University of Arizona. 1991; Graduate Brochure; "Specialization in Watershed Management". Univ. of Arizona, Tucson, AZ.

Wilm, H.G., G. Ayer, C.W. Barney, E.A. Colman, R.E. Dils, E.J. Fjeldsted, B. Frank, T.B. Plair, and G. Salmond. 1957. The Training of Men in Forest Hydrology and Watershed Management. J. of Forestry 55(4):268-272.