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RAY K. LINSLEY AWARD

The American Institute of Hydrology (AIH) established this award in 1986 to honor the first Vice President of AIH, Ray K. Linsley-one of the truly great leaders in the hydrologic sciences. The award is presented annually, on the recommendation of the AIH Awards Committee, for a major contribution to the field of surface water hydrology. The first Ray K. Linsley Award was presented to Peter O. Wolf at the AIH International Conference on Advances in Ground-Water Hydrology in Tampa, Florida on November 17, 1988.

Citation- *Vijay P. Singh*

With great pride, privilege and pleasure, I have the honor of introducing Dr. David A. Woolhiser, formerly of Agricultural Research Service of the U. S. Department of Agriculture, the year 2000 winner of the Ray K. Linsley Award of the American Institute of Hydrology. Dr. Woolhiser is known far and wide for his outstanding contributions in surface water hydrology, vadose zone hydrology, and water quality hydrology.

There are several areas of hydrology and hydraulics where Dr. Woolhiser's work has been truly exceptional and groundbreaking. His outstanding contributions can be distinguished in two major categories: (1) development of hydrologic concepts and consequent understanding of hydrologic processes, and (2) development of techniques of solution. In the first category, his contributions span such hydrologic themes as rainfall-runoff modeling, infiltration, evaporation, flow over porous beds, soil erosion, and chemical transport. The second category of contributions include development of analytical, numerical, probabilistic and stochastic solutions for many of the themes indicated in the first category..

Singling out any particular contribution as Dr. Woolhiser's most influential work is quite difficult. His 1967 paper with Professor J. A. Liggett of Cornell University on A unsteady one-dimensional flow over a plane-The rising hydrograph@ published in Water Resources Research gave birth to what has since been known as the kinematic wave number. Indeed we could just as well designate this number as the Woolhiser-Liggett number in the spirit of Reynolds number or Froude number. This paper is one of the most cited works in the hydrologic literature and can be considered as perhaps the single most influential paper for establishing the kinematic wave theory as a physically sound modeling tool in surface water hydrology and later in other branches of environmental and water science and engineering. The kinematic wave number was further generalized in a paper published in 1980 in Water Resources Research by him and E. M. Morris of the Institute of hydrology at Wallingford in England.

For over three decades and a half, Dr. Woolhiser by himself as well as with his students and colleagues has published a number of seminal papers on different aspects of kinematic wave modeling in Journal of Hydrology, Water Resources Research, ASCE Journals, Transactions of American Society of Agricultural Engineers, and others. These papers encompass different areas of water science, including rainfall-runoff modeling, surface irrigation, pollutant transport, soil erosion, to name but a few. For example, he proposed a number of geometric simplifications, such as converging section, composite section, cascade geometry, and so on, for representing watersheds. Some of these geometric representations are now in common use. His work with his doctoral student D. F. Kibler, who is now a well-known professor at VPI and State University, on kinematic shocks several follow-up studies by others. In fact, this work has enhanced our understanding of kinematic shocks and shed light on how they are formed, how they propagate, and how they can be modeled.

In a similar vein, his work on surface irrigation published in 1975 as a chapter in a book on unsteady flow is an outstanding contribution. For the first time, issues related to free boundary problems arising in surface irrigation during flow advance and recession were clarified. This work has formed the basis of may kinematic wave theory-based surface irrigation modeling studies, and is responsible, to a great extent, for acceptance of kinematic wave modeling in agricultural irrigation.

Dr. Woolhiser, along with his doctoral student and later his colleague, R. E. Smith who himself is well known and is from the U. S. Department of Agriculture-Agricultural Research Service, was the first to develop a combined treatment of surface runoff and infiltration published in Water Resources Research in 1972. Indeed this outstanding work opened a new area of research and formed the basis of volumes of subsequent papers and dissertations that followed in later years around the globe. When infiltration is considered simultaneously with rainfall for runoff modeling, important issues, such as free boundary problems, shocks, etc. arise. Traditionally, the concept of rainfall excess is used in hydrology, even though this concept is an artifact. The Smith-Woolhiser work was the first attempt to better understand the role of infiltration in dynamics of runoff and develop a complete physically based model of surface runoff.

His pioneering work with J. K. Snyder on effects of infiltration on chemical transport published in 1985 in Transactions of American Society of Agricultural Engineers and other forums provided new insights into the dynamics of pollutant transport. Several of his graduate students, including myself, had the privilege of working with him on a rather versatile physically based runoff model, known as KINGEN. With the addition of an erosion component and improvements in the infiltration algorithm by R. E. Smith and D. C. Goodrich, this model has evolved into a much improved model called KINEROS2. This model is now used all over the world.

On another front, Dr. Woolhiser=s contributions in the area of stochastic hydrology are equally outstanding, pathbreaking, and impressive. His work, jointly with Professor P. Todorovic then at Colorado State University, on extreme floods published in Water Resources Research in 1972 broke new grounds in terms of providing a new phenomenogical probabilistic formulation for occurrence of floods. His several papers on stochastic modeling of space-time precipitation fields in southwestern U. S. are outstanding both in terms of physical understanding and the elegance with which stochastic concepts have been woven into the physically-based fabric of hydrologic processes. Similarly, he was one of the first to propose a stochastic treatment of erosion and sediment yield.

I could go on and on, but space limitations restrict me to keep my remarks short. Dr. Woolhiser is a unique researcher in creativity, originality and diversity of ideas. He has clearly distinguished himself with the concepts that have shaped the hydrology profession fundamentally and the way we look at it. He is simply a great man of hydrology. His accomplishments, spanning over four decades, are unusually significant and important. Some of his contributions have become an integral part of our profession. He stands tall in the field of hydrology not only because of his phenomenal productivity and ability and diversity of research contributions, but also because of some unique personality traits. His sharp intellect, brilliant mind, penetrating sense of inquiry, and keen farsightedness coupled with soft-spoken style, unassuming nature, common sense, and caring attitude have been his hallmarks. Those of us who have had the privilege of being his students and knowing him for over a quarter century still marvel at his scientific outlook and approach in life. Arguably, he taught us best by example and never sought credit for his own contribution in a joint effort. I can recall instances where his contribution was major but he received less credit and never blinked an eye. The hydrologic community is indeed fortunate to count Dr. Woolhiser among its elder statesmen. I am delighted to present Dr. Woolhiser as the winner of the Ray K. Linsley Award for the year 2000. The award could not be in finer hands.

Dr. Vijay P. Singh
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RAY K. LINSEY AWARD

Response *David A. Woolhiser*

I am deeply grateful to be selected for the year 2000 Ray K. Linsley Award of the American Institute of Hydrology. It is indeed an honor to join the illustrious list of previous recipients.

To paraphrase Isaac Newton, Ray Linsley is one of the giants upon whose shoulders I have stood. His books, Applied Hydrology (1949) and Hydrology for Engineers (1958) (both with Kohler and Paulhus) gave me an appreciation for hydrology as both and earth science and an applied science. The Stanford Watershed Model, with the insightful method of using a distribution function to handle spatial variation of runoff generation, gave me ideas as to how to treat small-scale spatial variability of saturated hydraulic conductivity in the context of the distributed model, KINEROS. During the 1950s and early 60s, Linsley encouraged his students to work on the mathematical description of overland and channel flow, resulting in dissertations by Richey(1954), Behlke (1957), Liggett (1959) and Morgali (1963).

My connection with this work was through my collaboration with a colleague, Jim Liggett, at Cornell University. He had utilized the method of characteristics for the overland flow problem in his Ph.D. dissertation at Stanford and solved the equations with analytic and graphical techniques. One day Jim walked into my office, put a FORTRAN program on my desk and said "will this work?". After studying it for a while, I was hooked on the unsteady, free-surface flow problem. In our collaboration, we utilized numerical solutions on both rectangular grids and characteristic nets. Those were the early days of numerical solutions of hyperbolic partial differential equations and we learned a great deal about approximation and stability of finite difference schemes. Although we began this study with the conviction that one should use the complete de Saint Venant equations, we found that the kinematic approximation was adequate for most hydrologic cases. Incidentally, if names should be applied to what is now known as the kinematic wave number, Liggetts name should be first because he was responsible for writing the equations in dimensionless form.

As I look back over my career, It is clear that any contributions of mine have been greatly influenced by chance, privilege and being in the right place at the right time. It was pure chance that I became involved in hydrology. I enrolled in the Agricultural Engineering Program at the University of Wisconsin because I was interested in farming and because my sister knew someone who was in Agricultural Engineering at another University! I took a course in hydrology as a requirement of the Civil Engineering part of the curriculum and wrote my senior thesis on a hydrologic topic. However, I wasn't really excited about hydrology until I took a job with the Agricultural Engineering Department at the University of Arizona. It was on a research project financed by a state grant to investigate the possibility of artificial ground water recharge using surface runoff from high intensity thunderstorm rainfall. I also taught an undergraduate hydrology course. I instrumented an 18.5 square mile watershed near Tucson. Precipitation was measured with raingages on a one mile grid and runoff was measured in ponds and with a flume. I was impressed with the extreme spatial and temporal variability of thunderstorm rainfall and the need to treat hydrologic phenomena in a probabilistic sense. I was intrigued by the challenges inherent in describing hydrologic phenomena in a semi-arid environment and decided that I needed additional academic training.

I joined the Agricultural Research Service (ARS) of the USDA in 1958 and spent nearly a year in Tombstone supervising construction of a large measuring flume and servicing flumes and rain gages on the 60 square mile Walnut Gulch Experimental Watershed. I also shoveled a lot of aggregate and concrete! My observations at Walnut Gulch convinced me of the need for distributed runoff models. I finished an MS degree at the University of Arizona and then was transferred to Madison, Wisconsin, where I worked part time and pursued my studies for a Ph.D under Dr. Arno Lenz. My ARS supervisor at the time was Neal Minshall, a very experienced and thorough hydraulic engineer. He was the first one to show the nonlinearity of the surface runoff response of small watersheds from an analysis of watershed data. He also taught me a great deal about the importance of careful maintenance and calibration of instruments and of checking my calculations. I was then transferred to a new watershed center at Columbia, Missouri. Much of my time there involved design and installation of instrumentation of experimental watersheds near Treynor, Iowa.

I then joined the faculty in the School of Civil Engineering at Cornell University where I and a faculty member in the Department of Economics were hired on a U.S. Public Health Service training grant to help develop a graduate program in Water Resources Engineering. I found the areas of economics and systems analysis to be extremely interesting, but after my collaboration with Liggett, I decided to concentrate on hydrologic research.

I rejoined ARS at Fort Collins in 1967 and began an exciting period of research. I was stationed at the CSU Engineering Research Center and collaborated with the Hydrology program under Dr. V. Yevjevich and the Hydraulics program Under Dr. D. Simons. The excellent laboratory facilities provided an opportunity to work with real water as well as "electronic or digital water". I hired graduate students as research assistants. It was my privilege to work with extremely talented students such as Vijay Singh and many others, as well as ARS colleagues and with Colorado State University faculty members. Dr. Singh has mentioned some of my students and colleagues. There are many more whom I should like to cite, but the list would be long and there is a danger that I would omit some inadvertently. This was a truly great time in hydrology with the rapid development of digital computers and new ideas in deterministic and stochastic hydrology.

I transferred to ARS in Tucson in 1981 and had an opportunity to work with the unique data set from the Walnut Gulch Experimental Watershed and to collaborate with ARS staff and with students and faculty of the Department of Hydrology and Water Resources at the University of Arizona.

It has been my privilege to work with many extremely talented individuals, both students and colleagues, at the previously mentioned institutions as well as The Institute of Hydrology at Wallingford, England, Imperial College, London, Virginia Polytechnic and State University, and the University of Cordoba, Spain. Many of these persons were much better hydraulicians, mathematicians or probabilists than I and I learned a great deal from them. I also wish to express my gratitude to my employers, especially the Agricultural Research Service, who gave me a great deal of freedom to pursue interesting topics and to the laboratory and field technicians who collected the data I have used in my investigations. Without their excellent work, often under very difficult conditions, much of my work could not have been accomplished.

Finally, I should like to thank my wife, Kathryn, who has been my inspiration and my support since 1956. Her first introduction to hydrology was typing my M.S. thesis in the days of multiple carbons and a "no mistakes" criterion. Fortunately, our marriage survived that trauma! This award belongs to her as well.

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