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A Biographical Memoir by
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BY RUTH S. DEFRIES AND THOMAS DUNNE

M. GORDON WOLMAN'S INFLUENCE FLOWED beyond his considerable scientific achievements in fluvial geomorphology. He devoted his career to developing and teaching methods for applying Earth science to questions of environmental management and public policy. In doing so he created a legacy of published work, influential reports to government, and students inculcated with his profound commitment to applying science as public service. His work guided public policy related to water management and environmental problems throughout the world. Wolman pioneered interdisciplinary, systems-based approaches to solving complex societal problems ranging from land-use controls for limiting water pollution to river management for controlling disease vectors.

Known as "Reds" for his carrot-colored hair, Wolman was born in Baltimore, Maryland, in 1924 to Abel and Anna Wolman. He attended Haverford College in 1942 but was drafted into the navy after one semester. After World War II ended, he completed his undergraduate studies at the Johns Hopkins University in Baltimore with a B.A. in geology and All-American honors in lacrosse. Wolman received his master's and Ph.D. from Harvard University in geology. From 1951 to 1958 he worked as a hydrologist for the U.S. Geological Survey, where he focused on quantitative analysis of river channels and floodplains.

Wolman returned to Johns Hopkins University in 1958 as chair of the Isaiah Bowman Department of Geography. The department merged with the Sanitary and Water Resources Engineering Department in 1968 to become the Department of Geography and Environmental Engineering (DOGEE). He served as chair of DOGEE from 1970 to 1990. He then became director of the Center for Environmental Health Engineering at the Johns Hopkins Bloomberg School of Public Health while maintaining his faculty position in DOGEE.

Wolman and his wife, Elaine, raised four children: Elsa Wolman Katana, Abel G. Wolman, Abby W. McElroy, and Fredericka Wolman. At the time of his death he had two grandsons.

THE FATHER'S SON

Wolman's intellect and career sprang from his lifelong companionship and conversations with his father, Abel Wolman. Abel Wolman's extraordinary achievements included demonstration of a method for chlorination of drinking water supplies (Wolman and Enslow, 1919). In addition to fundamental contributions in the science and engineering of sanitation, Abel Wolman advised governments on water management, from his home city of Baltimore to ministries throughout the developing world. His later work aimed to protect the public in the production of atomic power. Abel Wolman was a member of the National Academy of Sciences (elected 1963) and the National Academy of Engineering and received numerous other honors. Abel Wolman championed the linkages between public health and engineering at a time when these linkages were not obvious to many. Outbreaks of typhoid fever and the lack of safe drinking water compelled his life's work.

M. G. Wolman was the only child of Abel and Anne Wolman. The younger Wolman grew up in a home of robust discussion and dedication to public service. Later, the two men were constant companions and were often together in seminars and meetings on the Hopkins campus. When the older Wolman died in 1989, his son penned the biographical memoir for the National Academy of Sciences. Speaking to the inspiration from "Pop," he wrote,

> My friendship with my father, that I can recall, began when I was about four. Some months before he died he reminded me as we watched Charles Street traffic from his home that we used to "count cars" together from the third-floor window at Eutaw Place and Whitlock street in a row house in Baltimore. We counted separately Packards, LaSalles, Chevys, Pierce Arrows, and others. Then too we walked—and talked—to Druid Park Lake Drive and back. The talk did not stop until he died on February 22, 1989. My father and I worked together, traveled together, and reviewed each other's manuscripts. (Wolman, 2003)

Both Abel and M. G. Wolman's research and public service related to water, Abel with water for public supplies and M. G. with water in natural rivers. Both men were also dedicated to Johns Hopkins University, spending nearly their entire careers at that institution. The president of the university, Ronald J. Daniels, and the dean of engineering, Nicholas P. Jones, sent the following message to the Hopkins community when M. G. Wolman died: "For the first time since 1937, The Johns Hopkins University is without a Professor Wolman on its faculty. Reds and his father were giants. We are a far better university for the years they spent here, and far better people for having known and learned from them."

THE SCIENTIST

Wolman's scientific contributions began during his tenure at the U.S. Geological Survey and continued when he moved to Johns Hopkins. He was one of the founders of the modern quantitative approach to fluvial geomorphology. In the late 1950s and early 1960s he authored or coauthored several of the papers on river-channel morphology that significantly broadened the earlier paradigm of the graded river, and opened up a more flexible approach to explain the variety of river forms and behavior by applying hydraulic theory, laboratory experiments, and field measurement.

Approximately a dozen of his papers from this research period established many of the concepts and vocabulary that still dominate fluvial studies. The topics included channel adjustments to temporal and spatial changes in flow (Wolman, 1955); the formation of floodplains (Wolman and Leopold, 1957); the morphological significance of floods of various sizes (Wolman and Miller, 1960); meanders and other river-channel patterns (Leopold and Wolman, 1957, 1960); and knick points in river profiles (Wolman and Brush, 1960). Most of this work was summarized in the coauthored textbook *Fluvial Processes in Geomorphology* (Leopold et al., 1964). The book constituted the bible of the discipline for 20 years, and was reprinted in 1995, still with many stimulating ideas, not all of which have been fully explored.

Reds continued to work with students and other colleagues to extend knowledge of river channel behavior with his provocative, novel ideas. Wolman and Gerson (1978) extended his study of the magnitude and frequency of morphogenetically significant weather events from river channels to the hillslopes of watersheds. Yu and Wolman (1987) generalized Reds's earliest work on channel dimensions by demonstrating how flood discharge sequences control temporal fluctuations of channel geometry. With Grant et al. (1990) he extended systematic study of channel geometry into forested mountain ranges and also expanded his earlier work on channel-forming discharges.

In the 1960s Wolman turned his attention to an emerging public policy issue: sedimentation in stream channels of urban areas, and once again he wrote the definitive papers. These papers crystallized understanding and still provide the basis for regulation and channel restoration. His paper on the effects of construction on fluvial sediment (Wolman and Schick, 1967) was among the first to link urban land use and water quality. The research quantified increased runoff and sediment load from construction associated with urbanization and illustrated how such impacts should be expected to spread through a landscape over time, consonant with predictable trajectories of urban development (Wolman, 1967). In 1971 he wrote another important paper that demonstrated how the flood-prone areas of valley floors could be rapidly delineated through the use of simple field mapping without slow, expensive hydraulic data collection and computation, which continue to slow down the delineation of flood-prone lands and allow development to spread into dangerous areas faster than regulation and sound advice can be extended (Wolman, 1971a). Another influential paper (Wolman, 1971b) was his review of water quality, which was the first to illustrate temporal trends in the quality of the nation's rivers and the extremely nonlinear response of water quality to cleanup efforts. He re-visited this problem in another coauthored *Science* article (Smith et al., 1987). This work became the impetus for the National Water-Quality Assessment Program (NAWQA) of the U.S. Geological Survey, aimed at tracking trends in the nation's water quality. Later he summarized downstream impacts of dams on channel bed sediment and morphology (Williams and Wolman, 1985), leading to policy discussions about the environmental consequences of large dams.

The honors he received in recognition of his research are exceptional in their level of distinction and their range. He was elected to the three most prestigious and exclusive scientific bodies in the nation (National Academy of Sciences, elected in 1988; American Academy of Arts and Sciences; and American Philosophical Society). He is an elected fellow of all the major societies in Earth and environmental science. He has received the premier honors of scientific societies ranging from the American Geophysical Union's Horton Medal and the Geological Society's Penrose Medal to the Rachel Carson Award for his contributions to the conservation of the Chesapeake Bay.

IN SERVICE TO HUMANITY FROM LOCAL TO GLOBAL

Reds Wolman set an extraordinary standard for public service. He served as a member and officer of a long series of committees, boards, and commissions—national, international, regional, and local—that provided advice to government and addressed emerging or enduring environmental problems. He devoted considerable service to the state of Maryland. His work in the 1960s to link runoff from construction projects with sedimentation of Maryland's steams led to the first state regulations in the nation to address the problem. In the 1990s he chaired the Oyster Roundtable to develop a plan to restore the Chesapeake Bay's shellfish, which were suffering from disease and overharvesting. Beginning in 2003 he chaired Maryland's Advisory Committee on the Management and Protection of the State's Water Resources, which led to a state law requiring a water management plan before building.

Beyond his home state of Maryland, Wolman used his expertise in fluvial geomorphology to address a range of global issues. His service on international committees addressed issues ranging from the impacts of soil erosion on crop productivity to links between population, land use, and environment.

His colleagues in these endeavors frequently elected him to leadership positions in societies, where he gently provoked them to reflect on the future conditions and the potentials of their disciplines. He was both internationalist in perspective and nationalist in the most constructive sense of the word. He had a commitment to social justice and equity in his choice of environmental science problems to work on, and he exemplified the model of a truly ethical scientist-statesman. Observing him inspired all of his colleagues in the environmental sciences to do better for humanity.

From these activities Wolman published an influential stream of papers, reports, and book chapters on important resource problems facing the United States and the world. These reports deserve attention mainly because the problems are so important: energy (Wolman, 1978a; Fearon and Wolman, 1986); human response to flood hazard in developed and developing nations (Wolman, 1978b); water supply and human health (Wolman, 1969, 1995); pollution of waterways (Wolman, 1974); the management of large rivers (Wolman, 1989); the transmission of water-borne diseases in tropical rivers (Rosenfield et al., 1977); land degradation and soil productivity (Wolman and Fournier, 1987); water resources (Wolman, 1976); and toxic waste disposal policies (Wolman, 1984).

In this body of work one sees how an outstanding field scientist with a strong appreciation of a wide variety of environmental processes struggles to develop rational methods for addressing these refractory problems. Some of these pieces are major contributions in the application of Earth science to human affairs. They became stimuli for influential advisory committee reports, government regulatory or assessment programs, and research programs. As with his scientific literature, these reports often became benchmark papers that allowed others to make progress on a very complicated subject. For decades geomorphologists, engineers, and stream ecologists have referred to those papers. Wolman's work also guided the application of systems analysis and interdisciplinary approaches to derive solutions for environmental problems (Wolman, 1978c; Holmes and Wolman, 2001).

THE EXPERIMENTER IN INTERDISCIPLINARY RESEARCH AND EDUCATION

Every Thursday afternoon during spring semester, Wolman donned his green rubber boots and piled into the van with his students in tow. These were the renowned field trips to streams, farms, and suburban developments around Baltimore. Here Wolman was in his element, beyond the academic halls and into the messy world of real-life environmental problems. Wolman took his students to urban streams, explaining principles of fluvial geomorphology, urbanization, ecological succession, and transport of pollutants to weave an interdisciplinary vision of the stream's behavior and evolution. Other trips would venture into the rolling hills north of Baltimore, where Wolman explained the geology, soils, history of farming, and potential for soil erosion and sedimentation with impending suburban expansion. The message to students was to understand the environment in all of its complexity, and to avoid focusing exclusively on any single disciplinary perspective.

Wolman extended his interdisciplinary vision into the design of educational programs at DOGEE during his reign as chair from 1970 to 1990. He presided over one of the first and most ambitious experiments in interdisciplinary research and education. Wolman's approach was firmly rooted in his notion that "the rationality for interdisciplinary studies is based on the common observation that problems in the real world are not separable into disciplines" (Wolman, 1977). DOGEE's diversity of faculty reflected his breadth of vision, with scholarship ranging from microbiology to Marxist theory and operations research. The design of the graduate program exposed students to the humbling realization that a single discipline alone cannot solve environmental problems. He encouraged students to gain firm grounding in quantitative methods, systems analysis, and a core area of expertise, while maintaining knowledge of the breadth of disciplines required to solve real-world problems.

In 1977, nine years after DOGEE was established, Wolman published a characteristically analytical assessment of "Interdisciplinary Education: A Continuing Experiment." He noted the difficulties of establishing an interdisciplinary faculty and graduate program within a discipline-based academy, a problem that persisted till the time of his death and is likely to persist into the future. Despite these difficulties he concluded,

> A number of recurring environmental themes, such as the inseparability of natural and social processes, the existence of spillover effects or externalities, the problem of the commons, the existence of incommensurate and nonmonetary values, and the importance of large-scale natural processes undergoing dynamic and evolutionary change, appear to warrant continuing emphasis.

Wolman's legacy resides largely in the principles for interdisciplinary research that he strove to transmit to his many students: rigor, appreciation for multiple perspectives, service to humanity, and problem solving in a real-world context.

REFERENCES

Fearon, J. G., and M. G. Wolman. 1986. Shale oil: Always a bridesmaid? Forty years of estimating costs and prospects. *Energy Syst. Policy* 6(1):63-96.

Grant, G., F. J. Swanson, and M. G. Wolman. 1990. Pattern and origin of stepped-bed morphology in high-gradient streams, Western Cascades, Oregon. *Geol. Soc. Am. Bull.* 102:340-352.

Holmes, K. J., and M. G. Wolman. 2001. Early development of systems analysis in natural resources management from Man and Nature to the Miami Conservancy District. *Environ. Manage.* 27:177-193.

Johns Hopkins Institutions, Communications and Public Affairs. n. d. Reds Wolman, 1924-2010. *http:// webapps.jhu.edu/jhuuniverse/featured/reds_wolaman.* Accessed March 21, 2011.

Leopold, L. B., and M. G. Wolman. 1957. River channel patterns: Braided, meandering and straight. USGS Professional Paper 282-B.

Leopold, L. B., and M. G. Wolman. 1960. River meanders. *Geol. Soc. Am. Bull.* 71:769-794.

Leopold, L., M. G. Wolman, and J. Miller. 1964. *Fluvial Processes in Geomorphology.* San Francisco: W. H. Freeman.

Rosenfield, P. L., R. A. Smith, and M. G. Wolman. 1977. Development and verification of a schistosomiasis transmission model. *Am. J. Trop. Med. Hyg.* 26(3):505-516.

Smith, R. A., R. B. Alexander, and M. G. Wolman. 1987. Water-quality trends in the nation's rivers. *Science* 235:1607-1615.

Williams, G., and M. G. Wolman. 1985. Downstream effects of dams on alluvial rivers. USGS Professional Paper 1286.

Wolman, A., and L. Enslow. 1919. Chlorine absorption and the chlorination of water. *J. Ind. Eng. Chem.* 11(3): 209-213.

Wolman, M. G. 1955. The natural channel of Brandywine Creek, Pennsylvania. USGS Professional Paper 271.

Wolman, M. G. and L. M. Brush. 1960. Knickpoint behavior in noncohesive material: A laboratory study. *Geological Society of America Bulletin,* 71:59-74.

Wolman, M. G. 1967. A cycle of sedimentation and erosion in urban river channels. *Geogr. Ann. A* 49(2/4):385-395.

Wolman, M. G. 1969. Survival: Man and water. A community health forum. Mary Scott Newbold Symposium. *Trans. Stud. Coll. Phys. Phila., 4 Ser.,* 36(4):185-214.

Wolman, M. G. 1971a. Evaluating alternative techniques of floodplain mapping. *Water Resour. Res.* 7(6):1383-1392.

Wolman, M. G. 1971b. The nation's rivers, *Science* 174(4012):905-918.

Wolman, M. G. 1974. Stream standards: Dead or hiding? *J. Water Pollut. Con. F.* 46(3):431-437.

Wolman, M. G. 1976. Crisis and catastrophe in water-resources policy. *J. Am. Water Works Assoc.* 68:136-142.

Wolman, M. G. 1977. Interdisciplinary education: A continuing experiment. *Science* 198(4319):800-804.

Wolman, M. G. 1978a. Energy, environment, and the geosciences. In *The Impact of the Geosciences on Critical Energy Resources,* eds. C. A. Burk and C. L. Drake, pp. 85-102. AAAS Selected Symposium 21. Boulder: Westview.

Wolman, M. G. 1978b. *Floods and People: A Geological Perspective.* Report of the Committee on Geology and Public Policy. Need city: Geological Society of America.

Wolman, M. G. 1978c. Interacting systems of society, man and nature in monitoring the world's environments. *J. Environ. Manage.* 6:201-208.

Wolman, M. G. 1984. Toxic substances in the environment: Some key issues. In *The Fate of Toxics in Surface and Ground Waters.* Proceedings of the Second National Water Conference, January 24-25, Philadelphia, ed. J. Wilson, pp. 15-22.

Wolman, M. G. 1985. Soil erosion and crop productivity: A worldwide perspective. In *Soil Erosion and Crop Productivity,* eds. R. F. Follett and B. A. Stewart, pp. 9-21. Madison, Wisc.: American Society of Agronomy.

Wolman, M. G. 1989. Erosion control and reservoir deposition. In *Taming the Yellow River: Silt and Floods,* eds. L. M. Brush, M. G. Wolman, and B.-W. Huang, pp. 139-161. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Wolman, M. G. 1995. Human and ecosystem health: Management despite some incompatibility. *Ecosyst. Health* 1(1):9-14.

Wolman, M. G. 2003. Abel Wolman. In *Biographical Memoirs of the National Academy of Sciences,* vol. 83, p. 4. Washington: D.C.: The National Academies Press.

Wolman, M. G., and F. G. A. Fournier, eds. 1987. *Land Transformation in Agriculture.* SCOPE, vol. 32. West Sussex: John Wiley and Sons. (Author with F. G. A. Fournier of chapters 1, 5, and 7.)

Wolman, M. G., and R. Gerson. 1978. Relative scales of time and effectiveness of climate in watershed geomorphology. *Earth Surf. Proc. Land.* 3(2):189-208.

Wolman, M. G., and L. B. Leopold. 1957. River flood plains: Some observations on their formation. USGS Professional Paper 282-C.

Wolman, M. G., and J. P. Miller. 1960. Magnitude and frequency of forces in geomorphic processes. *J. Geol.* 68(1):54-74.

Wolman, M. G., and A. P. Schick. 1967. Effects of construction in fluvial sediment, urban and suburban areas of Maryland. *Water Resour. Res.* 3:451-464.

Yu, B., and M. G. Wolman. 1987. Some dynamic aspects of river geometry. *Water Resour. Res.* 23:501-509.

SELECTED BIBLIOGRAPHY

1955

The natural channel of Brandywine Creek, Pennsylvania. USGS Professional Paper 271.

1957

With L. B. Leopold. River channel patterns: Braided, meandering and straight. USGS Professional Paper 282-B.

With L. B. Leopold. River flood plains: Some observations on their formation. USGS Professional Paper 282-C.

1960

With L. B. Leopold. River meanders. *Geol. Soc. Am. Bull.* 71:769-794.

With J. P. Miller. Magnitude and frequency of forces in geomorphic processes. *J. Geol.* 68(1):4-74.

1964

With L. Leopold and J. Miller. *Fluvial Processes in Geomorphology*. San Francisco: W. H. Freeman.

1967

A cycle of sedimentation and erosion in urban river channels. *Geogr. Ann. A* 49(2/4):385-395.

With A. P. Schick. Effects of construction in fluvial sediment, urban and suburban areas of Maryland. *Water Resour. Res.* 3:451-464.

1971

Evaluating alternative techniques of floodplain mapping. *Water Resour. Res.* 7(6):1383-1392.

The nation's rivers. *Science* 174(4012):905-918.

1974

Stream standards: Dead or hiding? *J. Water Pollut. Con. F.* 46(3):431-437

1976

Crisis and catastrophe in water-resources policy. *J. Am. Water Works Assoc.* 68:136-142.

1977

Interdisciplinary education: A continuing experiment. *Science* 198(4319):800-804.

With P. L. Rosenfield and R. A. Smith. Development and verification of a schistosomiasis transmission model. *Am. J. Trop. Med. Hyg.* 26(3):505-516.

1978

With R. Gerson. Relative scales of time and effectiveness of climate in watershed geomorphology. *Earth Surf. Proc. Land.* 3(2):189-208.

Energy, environment, and the geosciences. In *The Impact of the Geosciences on Critical Energy Resources,* eds. C. A. Burk and C. L. Drake, pp. 85-102. AAAS Selected Symposium 21. Boulder: Westview.

Interacting systems of society, man and nature in monitoring the world's environments. *J. Environ. Manage.* 6:201-208.

1985

With G. Williams. Downstream effects of dams on alluvial rivers. USGS Professional Paper 1286.

1987

With B. Yu. Some dynamic aspects of river geometry. *Water Resour. Res.* 23:501-509.

With F. G. A. Fournier, eds. *Land Transformation in Agriculture.* SCOPE, vol. 32. West Sussex: John Wiley and Sons. (Author with F. G. A. Fournier of chapters 1, 5, and 7.)

With R. A. Smith and R. B. Alexander. Water-quality trends in the nation's rivers. *Science* 235:1607-1615.

1989

Erosion control and reservoir deposition. In *Taming the Yellow River: Silt and Floods,* eds. L. M. Brush, M. G. Wolman, and B.-W. Huang, pp. 139-161. Dordrecht, The Netherlands: Kluwer Academic Publishers.

1990

With G. Grant and F. J. Swanson. Pattern and origin of stepped-bed morphology in high-gradient streams, Western Cascades, Oregon. *Geol. Soc. Am. Bull.* 102:340-352.

1995

Human and ecosystem health: Management despite some incompatibility. *Ecosyst. Health* 1(1):9-14.