Introduction to the Proceeding of the Federal Interagency Sediment Monitoring Instrument and Analysis Research Workshop, September 9-11, 2003, Flagstaff, Arizona

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The need for reliable, cost-effective, spatially and temporally consistent data on sediment content and clarity of our Nation's waters has never been greater. Traditional uses of fluvial-sediment data in the United States (U.S.) have focused on engineering considerations relevant to the design and management of reservoirs and in-stream hydraulic structures, and dredging. Over the last two decades, information needs have expanded to include those related to contaminated sediment management, dam decommissioning and removal, environmental quality, stream restoration, geomorphic classification and assessments, physical-biotic interactions, the global carbon budget, and regulatory requirements of the Clean Water Act, including the U.S. Environmental Protection Agency's (USEPA's) Total Maximum Daily Load (TMDL) Program. The USEPA identifies sediment, including siltation and suspended solids, as the single most prevalent impairment of U.S. rivers and streams (U.S. Environmental Protection Agency, 2004).

Ironically, the substantial increase in the need for fluvial-sediment data has coincided with a general decline in national-level sediment-data collection as inferred by a two-decade decrease in the number of sites at which the U.S. Geological Survey (USGS) collects daily records of suspended-sediment discharge. The number of these sites increased rapidly in the years following World War II, and peaked at 360 in 1982 (Glysson, 1989; Osterkamp and Parker, 1991). By 2003, only 116 daily-record sediment sites were being operated in the 50 States, although suspended-sediment and bedload data were being collected periodically at 767 and 69 sites, respectively (U.S. Geological Survey, 2004). Any decrease in sediment monitoring should be of particular concern to the Nation in that the physical, chemical, and biological sediment damages in North America were estimated to total about $20 billion in 2004 (Osterkamp and others, 2004).

The traditional techniques used to collect and analyze those data, based on standard protocols (Edwards and Glysson, 1999; Porterfield, 1972), result in production of the most nationally consistent and reliable fluvial-sediment data available in the U.S. (Turcios and Gray, 2001). Production of sediment data by traditional techniques, however, can be manually intensive and time consuming; produce data with an accuracy that may be inferred but that is rarely unequivocally known; and require manual field deployment that may entail safety risks. Use of traditional techniques can also be relatively expensive. For example, an informal poll of selected USGS District offices in 2001 yielded estimates ranging from $20,000 to $65,000 to collect and publish a year's worth of daily suspended-sediment discharge values (Gray, 2002).

Over the last decade, there has been a substantial increase in the availability, measurement capabilities, and research and testing of instruments that purportedly produce continuous and (or) quantifiably accurate sediment-surrogate data that are safer, and (or) less expensive to obtain than by traditional techniques. Optical properties of water such as turbidity (nephelometry) and optical backscatter are the most commonly used surrogates for suspended-sediment concentration, but use of other techniques such as acoustic backscatter, laser diffraction, digital photo-optic, and pressure-difference technologies is increasing for concentration and, in some cases, particle-size distribution determinations in the field and laboratory (Gray and Gartner, 2004). Bedload and bed-material characteristics, and bed topography, also are being inferred from surrogate field measurements. At the same time, data-analysis capabilities have improved or are being developed to convert surrogate measurements into concentration and particle-size distribution statistics, suspended-sediment or bedload transport rates, or bed topography (see appendix 1).

This convergence of advanced instrument technologies and analytical capabilities represents an unprecedented opportunity to evaluate the capability to measure and (or) monitor one or more phases of fluvial sediment with a heretofore unprecedented continuity, temporal density, and known accuracy. If sediment-surrogate data can be shown to meet codified accuracy criteria and appropriate sediment-record computation techniques are applied, these technologies have the potential to revolutionize the way in which fluvial-sediment data are collected, analyzed, stored, and made available in the U.S.

In the U.S., the private sector and universities are in the forefront of developing the instruments for collecting the surrogate data, and for some of the analytical techniques. Not surprisingly, however, there are gaps in applicability due in part

to a lack of coordination of developmental activities. Additionally, assertions regarding instrument performance by manufacturers may fail to be substantiated through independent, unbiased evaluations; hence they are not, unto themselves, solely acceptable as proof of performance to the Technical Committee, Federal Interagency Sedimentation Project (Federal Interagency Sedimentation Project, 2004, Home Page). Hence, there is an important Federal role for coordination and performance testing of sediment-surrogate technologies that may enable development of new national guidelines on sediment-data production, storage, dissemination, and use.

The Federal Interagency Sediment Monitoring and Research Analysis Research Workshop ("workshop") was held in recognition of these factors, and also on four recommendations from the Federal Interagency Workshop on Turbidity and Other Sediment Surrogates (Gray and Glysson, 2003) which are summarized below:

- Technology Transfer and Communication: Increase technology transfer between groups and individuals with interests in turbidity and other sediment-surrogate technologies. A steering committee should be formed that includes a coordinator and topical expert advisers on turbidity and other sediment-surrogate technologies. Resources or activities associated with the steering committee may include publishing a newsletter, creating and maintaining a web-based compilation of information, supporting user groups and on-line help, transferring industrial technology to the environmental field, enhancing communication among producers and users of new technologies, and providing guidance to the Advisory Committee on Water Information and its Subcommittee on Sedimentation.

- Stakeholder and Peer Review: Keep the public and users of turbidity and other sediment-surrogate data informed of the issues involved in producing these data, including assumptions, limitations, methods, and applicability.

- Testing and Development Program for Instruments and Methods: Develop a program to foster research, testing, evaluation, and documentation of instruments and methods for measuring, monitoring, and analyzing water clarity and selected characteristics of fluvial sediment by using cost-effective, safe, and quantifiably accurate means. Technically supportable and widely available standard guidelines for sensor deployment, calibration, and data processing, including real-time data are needed. Acceptance criteria for data on selected parameters, such as suspended-sediment concentration, should be developed, endorsed by the Subcommittee on Sedimentation, and widely advertised to encourage methods and instrumentation development.

- Collection and Computation of Sediment-Surrogate Records: Develop standardized procedures for the collection of sediment-surrogate data. This should include protocols for instrument calibration and accuracy criteria for the derivative sediment data. A standard procedure for computation of sediment-discharge records should be developed for all sediment-surrogate records utilizing the fullest set of data.

The workshop was sponsored by the Advisory Committee on Water Information's Subcommittee on Sedimentation and held at the USGS Flagstaff Field Center, Arizona, September 9-11, 2003. The names, professional affiliations, and locations of the 70 participants representing several Federal agencies, universities, and the private sector registered for the workshop are provided in appendix 2.

The theme of the workshop was, "What are the Nation's fluvial-sediment-data needs, and how can those needs be met with:

- substantially increased temporal and (or) spatial resolution,
- a better and quantifiable accuracy,
- an expanded suite of measurement characteristics,
- reduced costs, and (or)
- a greater margin of safety

compared with traditional, manually intensive data-collection techniques?"

The scope of the workshop focused on the means for measuring, storing, analyzing, and disseminating data for the following sedimentary phases: suspended-sediment, bedload, bed-material, and bed-topography data. The degree of uncertainty in the production of fluvial-sediment data was considered with respect to each of the sedimentary phases.

Improved understanding of constituents sorbed to sediments is in part dependent on a better understanding of the mobility and fate of fluvial sediment. Although considerations related to solid-phase chemistry, and sediment-biotic interactions were beyond the scope of the workshop, it is expected that implementation of selected workshop recommendations will ultimately improve the ability to quantify these characteristics.

The overarching workshop goals were to:

- **Exchange Information** on research into new and improved methods and technologies for monitoring fluvial sediment, including suspended sediment, bedload, bed material, or bed topography and related properties; propose new research directions; and provide an opportunity to view field and laboratory techniques for characterizing selected properties of suspended sediment that currently are being used or tested.

- **Provide Forum** to consider the ways and means to achieve an agreed-upon vision for acquiring, analyzing, storing, and accessing the reliable, quantifiably accurate fluvial-sediment data needed by the Nation.
- **Make Clear and Tractable Recommendations** to the Advisory Committee on Water Information's Subcommittee on Sedimentation regarding research on sediment-monitoring instruments and analytical procedures.

The workshop comprised opening and closing plenary sessions, concurrent breakout sessions, and a field trip to the Colorado River at Glen Canyon Dam, and to USGS Arizona streamgaging stations on the Colorado River at Lees Ferry; the Paria River near Lees Ferry; and Moenkopi Wash during a flash flood.

The opening session served to introduce the theme, scope, and general goals of the workshop, and to outline workshop expectations. This was followed by four concurrent breakout sessions, the respective participants in which are listed in appendix 3. The breakout session titles and their respective leaders were:

- **Suspended-Sediment Measurement: Data Needs, Uncertainty, and New Technologies**, led by Roger A. Kuhnle and Daniel G. Wren.
- **Bedload-Transport Measurement: Data Needs, Uncertainty, and New Technologies,** led by Sandra E. Ryan, Kristin Bunte, and John P. Potyondy.
- **Bed-Material and Bed-Topography Measurement: Data Needs, Uncertainty, and New Technologies,** led by Christi A. Young and Vincent C. Tidwell.
- **Sediment Data: Management, Sediment-Flux Computations**, **and Estimates from New Technologies** led by Mark N. Landers and Larry A. Freeman.

The breakout session leaders were charged with providing a summary of their full findings and recommendations to a final plenary session held on the afternoon of September 11, 2003. Summaries of the respective topics included:

- Statements of the background, key elements, and relevant considerations,
- Lists of key problems and limitations, and
- Recommendations on how to proceed, if at all.

This report describes the principal deliberations, outcomes, and recommendations to the Subcommittee on Sedimentation from the Federal Interagency Sediment Monitoring Instrument and Analysis Research Workshop. This information is available for evaluation by the Subcommittee on Sedimentation which may opt to develop an action plan based on the recommendations that it endorses for consideration by the Advisory Committee on Water Information.

Extended abstracts supporting most of the presentations at the workshop are listed in appendix 4 of this report and are available only online at *http://water.usgs.gov/osw/techniques/sediment/sedsurrogate2003workshop/listofpapers.html*.

All formal workshop accomplishments were summarized through the activities of the four breakout sessions. Owing to differences in subject matter, the nature in which information was shared and the styles of leaders and participants, products from the breakout sessions were addressed and summarized separately. In an effort to avoid losing the intent and thrusts of each breakout session, these summaries are provided in the following sections without consideration to consistency in format. Where appropriate and useful to the reader, information obtained after the workshop is included in this report.

USGS-authored extended abstracts were reviewed and approved for publication by the USGS. Other extended abstracts listed in appendix 4 prepared by non-USGS authors did not go through the USGS review processes and therefore may not adhere to USGS editorial standards.

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