the sediment grains. The drag on vegetation and on topographic elements of the floodplain surface can be calculated by carefully applying fundamental fluid-mechanical principals. Doing so requires identification and appropriate approximation of the reference velocity in the drag equation, and accurate estimates of the floodplain plant geometries and spacings. For shrubs, calculations indicate that skin friction on leaves is negligible compared to form drag on stems and branches, whereas, for uncut grasses, skin friction on the fronds is of primary importance. Scaling relationships are developed for each shrub species for specific applications, so that the fluid mechanically important properties can be estimated from mean stem diameters, mean stem group diameters, and mean stem group spacings. Stem group spacings and diameters can be related to shrub-canopy spacings and diameters respectively, which are determined from aerial photographs in the applications.

A process-based model incorporating the necessary principles was developed and applied to a headwater tributary of East Plum Creek, Colorado. Calculations using the estimated decrease in density of the sandbar willows along this tributary accurately postdict the site of initiation of floodplain unraveling (transformation from a narrow, sinuous stream to a wide, straight one) that occurred during an extreme flood in 1965. Details of this application are presented in an accompanying poster. The model then is applied to Clark Fork of the Columbia River in the Deer Lodge Valley, Montana. This meandering fluvial system is an EPA Superfund site, because the flood-of-record in 1908 deposited several decimeters of contaminated tailings in the meander belt. The tailings killed a large fraction of the willows that had protected the floodplain from erosion, producing barren areas called "slickens". The floodplain model is used to calculate the floodplain shrub density that would be required to yield the measured stage and estimated discharge for the 1908 flood, and is then tested by comparing the measured to calculated tailings thicknesses. When applied to the present floodplain, the model predicts that a five-day flood with a recurrence interval of only a few decades would cause the fluvial system to unravel.

H41I-08 1045h

Process-Based Model for Computation of Erosion and Deposition on Shrub-Protected Banks

Jason W. Kean[1] (303-541-3041; kean@bechtel.colorado.edu)

J. Dungan Smith[2] (303-541-3004; jdsmith@usgs.gov)

[1]Department of Civil, Environmental, and Architectural Engineering, University of Colorado, Boulder, CO 80309, United States

[2]U.S. Geological Survey, 3215 Marine Street, Boulder, CO 80303, United States

Determination of erosion and deposition rates on riverbanks requires a detailed knowledge of the near-bank boundary shear stress field. Riverbanks typically are irregular in planiform geometry owing to the presence of vegetation on them, and the effects of vegetation-caused bank irregularity in reducing flow in the neighborhood of the toes of banks must be taken into account in calculating the appropriate boundary shear stress fields. Form drag on roots, stems, and branches of shrubs and trees that protrude into the flow must be carefully evaluated. Methods for calculating the boundary shear stress and sediment transport fields on and near vegetated banks have been developed over the past several years. More recently, the direct effects of roots, stems, and branches in reducing the shear stresses on banks have been investigated in conjunction with research on arroyo channels having nearly trapezoidal cross sections and banks covered with sandbar willow and tamarisk. A model for computing flow and sediment transport in such channels is presented and then used to demonstrate the relative importance of the various environmental factors and their interactions. The primary environmental factors include (1) the cross-sectional geometry of the flow, which controls the structure of the cross-sectional distribution of the streamwise-averaged boundary shear stress, (2) the micro topography of the bed and banks, which determines the local ratio of streamwise-averaged boundary shear stress to skin friction and, thus, the cross-sectional structure of the sediment transport field in the channel, and (3) the bed-sediment size distribution, which controls the importance of density stratification in the flow and, thereby, the vertical structure of the velocity field. The model demonstrates that woody vegetation on sloping banks affects the flow in several ways. First, it forces the high velocity core toward the center of the channel, increasing the streamwise-averaged boundary shear stress there, putting more bed sediment into suspension. At the same time it reduces the streamwise-averaged boundary shear stress on the sloping banks. Furthermore, it promotes a rearrangement and amplification of the micro topography on the bank, reducing the skin friction there, leading to a net deposition of suspended sediment on the sloping banks. In general, when present, the nature of the woody vegetation controls the cross-sectional geometry of the channel. Herbaceous vegetation can produce similar, but less dramatic, results.

H41I-09 1100h

Processes and Rates of Sediment and Wood Accumulation in Headwater Streams of the Oregon Coast Range, U.S.A.

Christine L May[1] (541-737-6574; christine_may@usgs.gov)

Robert E Gresswell[2] (541-750-7410; robert_gresswell@usgs.gov)

[1]Oregon State University, Nash Hall Oregon Sate University, Corvallis, OR 97331, United States

[2]USGS Forest and Rangeland Ecosystem Science Center, 3200 SW Jefferson Way, Corvallis, OR 97331, United States

Channels that have been scoured to bedrock by debris flows provide unique opportunities to calculate the rate of sediment and wood accumulation in low-order streams, to understand the temporal succession of channel morphology following disturbance, and to make inferences about processes associated with input and transport of sediment. Dendrochronology was used to estimate the time since the previous debris flow in unlogged basins in the central Oregon Coast Range. Changes in sediment and wood storage were quantified for 13 streams that ranged from 4 to 135 years post-disturbance. The volume of wood in the channel was strongly correlated with the time since the previous debris flow, and the accumulation rate was linear. The pattern of sediment accumulation was non-linear and appeared to increase as the storage capacity of the channel increased through time. Wood recruited from the local hillslopes and riparian areas functioned to store the majority sediment in these steep headwater streams. In the absence of wood, channels that have been scoured to bedrock by a debris flow may lack the capacity to store sediment and could persist in a bedrock state for a longer period of time. With an adequate supply of wood, low-order channels have the potential for storing large volumes of sediment in the interval between debris flows and can function as one of the dominant storage reservoirs for sediment in mountainous terrain.

H41I-10 1115h

Sediment Retention Dynamics and Vegetation Along Three Tributaries of the Chesapeake Bay

Katie Ross[1,2] (804-924-4303; kross@virginia.edu)

Cliff Hupp[2] (crhupp@usgs.gov)

Lauren Alexander[2,3] (lalexand@fas.harvard.edu)

[1]University of Virginia, Dept of Environmental Sciences 291 McCormick Rd. PO Box 400123, Charlottesville, VA 22904-4123, United States

[2]US Geological Survey, Reston, VA

[3]Harvard University, Cambridge, MA

Coastal Plain riparian wetlands in the Mid-Atlantic United States are the last place for sediment and contaminant storage before reaching critical estuarine and marine environments. The deteriorating health of the Chesapeake Bay has been attributed in part to elevated sediment loads. The purpose of this study is to investigate the effects of channelization and urbanization on sediment deposition and geomorphic processes along the Pocomoke and Chickahominy Rivers and Dragon Run, three Coastal Plain tributaries. Floodplain microtopography was surveyed in 100 x 100 m grids at three characteristic reaches along each river and woody vegetation analyses were conducted. Floodplain suspended sediment concentrations and short and long-term sedimentation rates were estimated at each reach using single stage sediment sampler arrays, clay pads and dendrogeomorphic techniques, respectively. Site hydroperiod and flow characteristics were determined from USGS gaging station records, floodplain water level recorders, and field observations. Channelized floodplain reaches along the Pocomoke River are flooded less frequently, have lower mineral sedimentation rates (2 mm/yr to 6 mm/yr) and woody species diversity than the unchannelized reaches. Along the Chickahominy River, floodplain wetlands close to urban centers are flooded more frequently, but have shorter hydroperiods (3.5 days/yr compared to more than 45 days/yr), lower sedimentation rates (1.8 mm/yr to 6.8 mm/yr), and lower woody species diversity (0.51 to 1.95 on the Shannon-Weiner diversity index) than floodplains further downstream. Suspended sediment delivery and deposition rates are significantly influenced by floodplain hydroperiod duration and channel-floodplain connectivity. These results suggest that understanding floodplain sediment dynamics and geomorphic processes with respect to dominant watershed landuse patterns is critical for effective water quality management and restoration efforts.

H41I-11 1130h

Influence of a Large Woody Debris Obstruction on Three-dimensional Flow Structure in a Meander Bend

Melinda D Daniels[1] (217-333-3652; mdnewell@uiuc.edu)

Bruce L Rhoads[1] (217-333-1322; b-rhoads@uiuc.edu)

[1]University of Illinois, 220 Davenport Hall 607 S. Matthews Ave, Urbana, IL 61820, United States

A field experiment has been conducted to assess the influence of a large woody debris (LWD) obstruction on three-dimensional flow through a meander bend of a small stream in East Central Illinois. Previous studies in unobstructed meander bends have shown that flow through a curved channel should develop a coherent three-dimensional structure characterized by large-scale helical motion. Many meander bends are complicated by naturally occurring persistent obstacles, such as living vegetation and LWD, that have the potential to profoundly disrupt flow structure. The results of this study show that the LWD obstruction systematically influences the three-dimensionality of flow through the bend, particularly the position of the high velocity core and the development of helicity. The high velocity core is positioned in the center of the channel upstream of and near the bend apex, but as flow approaches the LWD, it is steered toward the inner bank by the obstruction. Evolving helicity in the upstream portion of the bend is amplified by abrupt turning of the flow induced by the LWD. As the flow moves past the LWD, helicity diminishes rapidly and may even reverse its pattern of rotation. The net effect of the LWD obstruction is to reduce near-bank velocities along the outer bank downstream of the bend apex a critical locus for bank erosion in meander bends. Given the persistence of the LWD obstruction, which is anchored by a living tree, it probably has an important local influence on bend migration and evolution.

H41I-12 1145h

Floodplain Flow Resistance Greatly Enhanced by Woody Debris Jams created in Riparian Vegetation

Karen Prestegaard[1] (301-405-2982; kpresto@glue.umd.edu)

Kate Folk[1] (301-4014365; folk@geol.umd.edu)

[1]University of Maryland, Dept. of Geology, College Park, MD 20742, United States

Riparian vegetation is a significant component of floodplain flow resistance. We examined channel and floodplain flow resistance for flow events ranging from baseflow to significant floods associated with Hurricane Floyd. The study site is a steep boulder-bed stream with a narrow valley. For flow events up to bankful stage, flow resistance is created by boulders on the channel bed. At flow stages above bankfull, riparian vegetation is the major part of floodplain resistance. Floodplain flow velocities initially increase then drop dramatically during floods. During Hurricane Floyd, small woody debris carried into the floodplain forests developed a series of debris jams, <1 m high, along the edge of the stream. These debris jams created a series of steps in the energy gradient of the floodplain. The velocity of the water on the floodplain was almost zero within the steps and these steps became deposition sites for suspended sand. Sand accumulations on the floodplain was up to 2m in depth for this small channel. During the peak of the flood, flow velocities in the main channel were at or above critical (Fr >1), while adjacent floodplain velocities were almost zero. This interaction between floodplain vegetation and flow hydraulics forces the flood sediment transport zone into a narrow zone in the channel center. This influences both bed material and the long-term development of the valley.

H41J MC: 130 Thursday 1030h

A Strategy for the Advancement of Hydrologic Science I *(joint with ED)*

Presiding: **K W Potter,** Univ Wisconsin

H41J-01 1035h INVITED

Research Infrastructure for the Advancement of Hydrologic Science: Planning Highlights and Update

Roger C Bales (520-621-7113; roger@hwr.arizona.edu)

H

University of Arizona, Department of Hydrology and Water Resources, Tucson, AZ 85721-0011

In response to the need for research infrastructure in hydrologic sciences, a group of over 35 universities has formed a Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI). With support from the U.S. National Science Foundation, CUAHSI has initiated a science planning process aimed at building research infrastructure in three main areas: i) Long Term Hydrologic Observatories, to provide the consistent, integrated, long-term information from point to continental scales ii) a Hydrologic Information System program, to support the data, information, and analysis requirements of the community and iii) a Hydrologic Measurement Technology program to develop and operate state-of-the-art systems and provide support services for hydrologic research. Scientifically, this infrastructure initiative aims to support research to provide new understanding about priority questions in hydrologic and related sciences, including: i) spatial and temporal properties of precipitation and snow processes, ii) surface water generation and transport at scales from hectares to continental-scale basins, iii) linked water, carbon and other chemical cycles, and changes in response to varying temperature, precipitation and land-use patterns, iii) environmental stresses on aquatic and riparian ecosystems related to groundwater pumping and other perturbations, iv) basin-scale subsurface water and solute movement, particularly as related to patterns of precipitation, evapotranspiration and recharge, and v) feedback between regional evaporation and transpiration and patterns of precipitation and humidity. It has become apparent that the science infrastructure in hydrologic and related sciences is currently inadequate to meet many of these priority science questions and societal needs. Specifically, investments are needed to: i) maintain, supplement and upgrade existing field facilities, ii) establish measurement programs that can deliver consistent data over the long term, iii) provide ready access to cutting-edge mathematical, statistical, and computational tools, and iv) develop measurement capabilities that are not currently available.

URL: http://www.temple.edu/chr

H41J-02 1055h INVITED

What a Long-Term Hydrologic Observatory Might Look Like: Blueprint for a Mesoscale Experimental Watershed

Mark W Williams (303/492-8830; markw@snobear.colorado.edu)

INSTAAR and Geography , CB 450, University of Colorado , Boulder, CO 80309, United States

Our understanding of hydrology is limited by the quantity and quality of field observations. While there is a legacy of hydrologic observations at experimental watersheds conducted by the ARS, USGS, USFS, and NSF-LTER, almost all of these observations are in watersheds less than 100 km2 in area. The transfer of knowledge about processes that affect the quantity and quality of water from research and monitoring in small and relatively pristine watersheds to larger and more urban watersheds has not always been effective.

The essence of the mesoscale experimental watersheds is the establishment of research platforms for use by the hydrologic research community. These research platforms are analogous to research vessels that facilitate research for the oceanographic community. We propose to develop a series of experimental watersheds that provide broad coverage of the major hydrologic zones of the US, with each watershed providing a nested series of hierarchical measurements to a maximum area that ranges from 10,000 to 100,000 km2. Site selection and measurement type, location, and frequency are driven by specific science questions, so that the value added will provide advances in basic and applied hydrology not possible with present-day measurements. Common and consistent measurements will be taken along the main stem of the river, including soil moisture, groundwater level, meteorological parameters, water quantity and quality, and isotopic content. Intensive studies will be conducted at smaller, nested watersheds. Collaboration with existing programs is essential and we propose to develop a formal partnership with Federal agencies that have experimental watersheds. We will also address issues such as the operating budget and evaluation criteria.

URL: http://snobear.colorado.edu/Markw/mark.html

H41J-03 1115h INVITED

Infrastructure to Support Hydrologic Research: Information Systems

Upmanu Lall[1] (212 854 8905; ula2@columbia.edu)

Christopher j Duffy[2] (814 863 4384; cxd11@psu.edu)

[1]Columbia University, 500 W 120th St, 918 Mudd, MC 4711, Earth and Environ. Eng, New York, NY 10027, United States

[2]Pennsylvania State University, Civil Environmental Engineering, 212 Sackett Building, University Park, PA 16802, United States

Hydrologic Sciences are inherently interdisciplinary. Consequently, a myriad state variables are of interest to hydrologists. Hydrologic processes transcend many spatial and temporal scales, and their measurements reflect a variety of scales of support. The global water cycle is continuously modified by human activity through changes in land use, alteration of rivers, irrigation and groundwater pumping and through a modification of atmospheric composition. Since water is a solvent and a medium of transport, the water cycle fundamentally influences other material and energy cycles. This metaphor extends to the function that a hydrologic research information system needs to provide, to facilitate discovery in earth systems science, and to improve our capability to manage resources and hazards in a sustainable manner. At present, we have a variety of sources that provide data useful for hydrologic analyses, that range from massive remote sensed data sets, to sparsely sampled historical and paleo data. Consequently, the first objective of the Hydrologic Information Systems (HIS) group is to design a data services system that makes these data accessible in a uniform and useful way for specific, prioritized research goals. The design will include protocols for archiving and disseminating data from the Long Term Hydrologic Observatories (LTHOs), and comprehensive modeling experiments. Hydrology has a rich tradition of mathematical and statistical modeling of processes. However, given limited data and access to it, and a narrow focus that has not exploited connections to climatic and ecologic processes (among others), there have been only a few forays into diagnostic analyses of hydrologic fields, to identify and evaluate spatial and process teleconnections and an appropriate reduced space for modeling and understanding systems. The HIS initiative consequently proposes an investment in research and the provision of toolboxes to facilitate such analyses using the data systems developed, with the goal of addressing specific hydrologic puzzles. This initiative will also support the development of methods to improve our ability to formulate conceptual and operational models for estimating hydrologic fluxes at ungaged and poorly gaged locations and time periods. Operational modeling of large scale hydrologic systems coupled to other earth systems is just now coming into vogue, and will be aggressively supported by the data initiatives at the LTHOs, and by the investment in new Measurement Technology. While we recognize that new ways of problem formulation and reduction are crucial to progress in modeling such systems, methods of data assimilation hold the promise for correcting the trajectories of existing models and for checking key modeling assumptions. Hence, we advance this component as part of an information system (defined through data, access and visualization tools, and numerical and statistical modeling tools) that may provide immediate improvements in hydrologic forecasting and applications. Finally, an HIS facility that embodies the components enumerated above, provides an excellent venue for the training of scientists and as a meeting place for scientists to plan new experiments, test hypothesis with data, explore improvements in models or visualization tools, and to generate new research ideas. This think tank component will add to the vitality of the field of hydrology as a scientific discipline.

H41J-04 1135h INVITED

A Framework for Instrumentation Infrastructure Support For Hydrologic Research

John S Selker[1] (541-737-6304; selkerj@engr.orst.edu)

Marc Parlange[2] (410-516-6042; mbparlange@jhu.edu)

[1]John S. Selker, Rm 240 Gilmore Hall Oregon State University, Corvallis, OR 97331, United States

[2]Marc Parlange, DOOGE Johns Hopkins, Baltimore, OR, United States

The Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI) formed as a means for infrastructure development for research in hydrologic sciences. The three major research support thrusts of UCAHSI are the establishment of long-term hydrologic observatories, the establishment of an information support service for hydrologic data and models, and the establishment of support for field hydrologists in carrying out their research. This presentation addresses the instrumentation support activity. We will present the science plan for the UCASH Hydrologic Measurement Division, which will support a broad range of instrumentation support for geophysical, surface water, groundwater and micro-meteorology, as well as training in the design and use of field equipment in hydrology. This university-based support service will fundamentally transform scientists ability to make field measurements by making available literally millions of dollars in instrumentation WITH technical support in the design, installation, and field operation of these equipment. The state of the development and how to get involved in the establishment of this new service will be presented.

URL: http://www.temple.edu/chr/

H42A MC: Hall D Thursday 1330h

A Strategy for the Advancement of Hydrologic Science II *(joint with ED)*

Presiding: **R C Bales,** University of Arizona

H42A-0335 1330h INVITED POSTER

The Upper Rio Grande Basin as a Long-Term Hydrologic Observatory - Challenges and Opportunities

Everett Springer[1] (505-667-0569; everetts@lanl.gov)

Christopher Duffy[2] (cxd11@psu.edu)

Fred Phillips[3] (phillips.nmt.edu)

James Hogan[4] (jhogan@sahra.arizona.edu)

C L Winter[5] (winter@lanl.gov)

[1]EES-10, MS J495 LANL, Los Alamos, NM 87545, United States

[2]Dep. of Civil and Environmental Eng., 212 Sackett Building Penn State University, University Park, PA 16802, United States

[3]Hydrology Program, Dep. of Earth and Environmental Science New Mexico Tech, Socorro, NM 87801, United States

[4]SAHRA, P.O. Box 210011 University of Arizona, Tucson, AZ 85721-0011, United States

[5]T-7, MS B256 LANL, Los Alamos, NM 87545, United States

Long-term hydrologic observatories (LTHO) have been identified as a key element to advance hydrologic science. Issues to be addressed are the size and locations of LTHOs to meet research needs and address water resources management concerns. To date, considerable small watershed research has been performed, and these have provided valuable insights into processes governing hydrologic response on local scales. For hydrology to advance as a science, more complete and coherent data sets at larger scales are needed to tie together local studies and examine lower frequency long wavelength processes that may govern the water cycle at the scale of river basins and continents. The objective of this poster is to describe the potential opportunities and challenges for the upper Rio Grande as a LTHO.

The presence of existing research programs and facilities can be leveraged by a LTHO to develop the required scientific measurements. Within the upper Rio Grande Basin, there are two Long-Term Ecological Research sites, Jornada and Sevilleta; Los Alamos National Laboratory, which monitors the atmosphere, surface water and groundwater; a groundwater study is being performed by the USGS in the Albuquerque Basin to examine recharge and water quality issues. Additionally, the upper Rio Grande basin served as an USGS-NAWQA study site starting in the early 1990's and is currently being studied by SAHRA (NSF-STC) to understand sources of salinity of the river system; such studies provide an existing framework on which to base long-term monitoring of water quality.

The upper Rio Grande Basin has a wealth of existing long-term climate, hydrologic and geochemical records on which to base an LTHO. Within the basin there are currently 122 discharge gages operated by the USGS; and many of these gages have long-term records of discharge. Other organizations operate additional surface water gages in the lower part of the basin. Long-term records of river chemistry have been kept by the USGS, U. S. Bureau of Reclamation, IBWC and EBID. Significantly, these records extend through periods of climate extremes, notably the 1950's drought. One challenge that the Rio Grande faces as a LTHO is combining datasets maintained by different agencies in order to address research questions at this spatial and temporal scale.

Challenges facing the development of a LTHO on the Rio Grande include instrumentation over steep topographic and biological gradients that exist. Political issues surrounding any basin can create problems for making long-term measurements. Current water resources management requires a greater scientific understanding of coupled processes, serious improvements in predictive capability and available computational resources, both of which require a comprehensive hydrologic monitoring system beyond any which exist today.