67th Annual Meeting of the

Rocky Mountain Hydrologic Research Center

Program and Abstracts

October 5, 2012
Natural Resources Research Center,
Building ~~A~~ C

Fort Collins, Colorado
Rocky Mountain Hydrologic Research Center

The forerunner of the Rocky Mountain Hydrologic Research Center was the Rocky Mountain Hydraulic Laboratory which was organized under the laws of the State of Colorado on September 5, 1945. Chesley Posey, professor at University of Iowa, found a site for an outdoor laboratory on the North St. Vrain Creek below Highway 7 near Allenspark, Colorado (cover photograph). At this 20-acre site, several flumes and support structures were constructed for purposes of hydraulic research; portions of those flumes and buildings are visible today and the facility has received designation as a historic landmark. Initial research was focused on bridge scour and open channel hydraulics. About 1960, the hydraulic research declined and the site has been used for more diverse types of hydrologic and ecologic research in recent years. In 1991, the name of the group was changed to the Rocky Mountain Hydrologic Research Center to reflect the newer goals for conducting a broader range of investigations. The site has had little disturbance in the last 50-years and is still available for research proposals. Anyone interested should contact one of the trustees of the center listed below.

Current officers

Board of Trustees

Cover photo: *Rocky Mountain Hydraulic Laboratory located on North St. Vrain Creek*
Photo credit: *John Moody*

67th Annual Meeting of the Rocky Mountain Hydrologic Research Center

October 5, 2012
Natural Resources Research Center, Building A
Fort Collins, Colorado

Presenters, affiliation, and presentation title

8:30 – 9:00	**Registration and PowerPoint loading**
9:00 – 9:10	**Greg Cronin**, President of the Rocky Mountain Hydrologic Research Center. *Introductory remarks*
9:10-9:30	**Brandon Buder, Mike Depaolo, Tate Fairbanks, and Shawn Wirth,** University of Colorado Boulder. *Hydraulic considerations for possible suspension bridge over the North St. Vrain Creek*
9:30-9:50	**Gregory Tucker,** Cooperative Institute for Research in Environmental Science (CIRES) and Department of Geological Sciences, University of Colorado Boulder. *Using repeat lidar imagery to measure topographic change produced by a large flood event on the Rio Puerco, New Mexico*
9:50-10:10	**Evan Pugh**, Department of Geological Sciences, University of Colorado Boulder. *A Conceptual model of water-related impacts from bark beetle infestations*
10:10-10:30	**Sandra Ryan,** US Forest Service, Rocky Mountain Research Station, Fort Collins. *Wildfire impacts on stream sedimentation: revisiting the Boulder Creek Burn in Little Granite Creek*
10:30-11:50	**BREAK**
10:50-11:10	**Joel Sholtes,** Civil and Environmental Engineering Department, Colorado State University. *River management under climate change: tools for planning under uncertainty*
11:10-11:50	**John Sanderson,** The Nature Conservancy. *Planning for healthy rivers while Colorado plans its water future. Invited Presentation*
11:50-13:00	**LUNCH BREAK**
13:00-13:20	**John Moody,** US Geological Survey, National Research Program. *How to predict the start of runoff after wildfire*
13:20-13:40	**Sam Litschert,** Earth Systems Institute, Fort Collins. *Geospatial tools for prefire planning and postfire analysis*
13:40-14:00	**Amanda Schmidt,** US Geological Survey, Boulder. *Experimental evaluation of the potential of wildfire affected soils and sediment to impact drinking water treatment processes*
14:00-14:40	**Lee MacDonald,** Colorado State University. *Effects of fires on runoff and erosion: What can we expect from the High Park fire? Invited Presentation*
14:40-15:00	**BREAK**
15:00-15:20	**Eleanor Griffin,** US Geological Survey, Boulder. *Runoff and sediment transport following the High Park Fire: observations from the northern boundary, Hewlett Gulch Area*
15:20-15:40	**Dan Baker,** Department of Civil and Environmental Engineering, Colorado State University. *Cache la Poudre River post-fire sediment and aquatic insect monitoring*
15:40-16:00	Discussions and end of day wrap-up
16:00-17:00	RMHRC Board Meeting

Invited Speakers

John Sanderson

Director of Conservation Science, The Nature Conservancy

Brief Biography from The Nature Conservancy website:

John’s career in conservation fell from the sky, so to speak. As an undergrad pursuing a degree in aeronautical engineering, Sanderson realized his true calling was the great outdoors. A post-college stint in the Peace Corps working on a forest program in West Africa sealed the deal. He attended the University of Vermont where he received a master’s degree in botany. It was also during this time that Sanderson developed a little-known love affair with mosses and lichens, particularly those that grow in wetlands.

Now armed with a Ph.D. in ecology from Colorado State University, Sanderson co-directs the Center for Conservation Science and Strategy. In that capacity, John manages a staff of scientists and project directors to deliver conservation outcomes that range from ensuring adequate streamflow for endangered fish in the Yampa River to keeping hundreds of thousands of acres on the Great Plains intact to support native wildlife from prairie dogs to antelope.

Although he might be trying to understand how energy development can be compatible with sage grouse one day and discussing a new location of a globally rare cliff-dwelling plant the next, John spends most of his time working on rivers. Much of John’s energy over the past few years has been focused on a statewide planning process for meeting the water needs of Colorado’s growing population while maintaining healthy rivers. This planning process has produced a map of important streams in Colorado as well as a tool to evaluate how water management puts rivers at risk. Plans and tools are valuable, but it’s not where to conservation happens, so John also works on several on-the-ground projects. Among these projects is collaboration with municipalities to explore new ways to design and manage water supply systems and efforts with land managers to restore streamside (riparian) ecosystems.

Lee MacDonald

Department of Forest, Rangeland, and Watershed Stewardship
Colorado State University

Dr. Lee MacDonald was a professor of land use hydrology in the Watershed Science Program at Colorado State University from 1990 to 2012. He has now (mostly) retired from active teaching, but he is still advising graduate students and working on a variety of research and education projects in Colorado, California, and Vietnam. His academic training includes a B.S. in human biology from Stanford, a M.S. in resource ecology from the University of Michigan, and a Ph.D. in forest hydrology from the University of California at Berkeley. Before his Ph.D. he spent five years setting up research and training programs in developing countries for the United Nations University in Tokyo. He also has worked as a hydrologist for the U.S. Forest Service and as a consultant.

Dr. MacDonald's research focuses on the effects of fires, forest management, and roads on runoff, erosion, sediment yields, and stream channel characteristics. He has advised 40 graduate students and published more than 50 peer-reviewed articles, monographs, and book chapters. He recently served on a National Academy of Sciences panel to assess the hydrologic effects of a changing forest landscape, and he has given dozens of invited workshops and lectures throughout the U.S., Europe, Asia, and the Pacific. He has taught courses on land use hydrology, field measurements, monitoring, watershed problem analysis, hillslope hydrology, wetlands, cumulative watershed effects, and international watershed management. More details and links to his publications and student theses can be found on his web site.

Lee H. MacDonald
Professor, Watershed Science Program
Dept. of Ecosystem Science and Sustainability
Colorado State University
Fort Collins, CO 80523-1476
Tel. 970-215-5311; Fax: 970-495-1320
lee.macdonald@colostate.edu
http://welcome.warnercnr.colostate.edu/~leemac/

ABSTRACTS

Hydraulic considerations for possible suspension bridge over the North St. Vrain Creek

Brandon Buder, Mike Depaolo, Tate Fairbanks, and Shawn Wirth

University of Colorado, Boulder

We were asked to explore the possibility of building a suspension bridge over the North St. Vrain Creek near Allenspark, Colorado to provide access the historic Rocky Mountain Hydraulic Lab (RMHL) on the left bank (north side) of North St. Vrain Creek. North St. Vrain Creek drains Wild basin on the eastern slope of Rocky Mountain National Park and the elevation of the stream channel at the RMHL is approximately 2530 m (8300 feet). The slope of the creek is about 0.06 and the flow is well over 2.83 $m^3 s^{-1}$ (100 cfs in early summer) but rarely drops below 0.85 $m^3 s^{-1}$ (30 cfs) in September.

Two sites for the suspension bridge were investigated. Cross sections of the terrain on both banks were surveyed to the present water level (29 September 2012) and elevation of high water marks were recorded. These sites were picked by considering possible flood flows from summer convective storms and extreme floods that might follow a wildfire. We will introduce suspended and suspension bridges types, and describe a basic overview of what each may look like at this location. A rough budget will be presented.

Using repeat lidar imagery to measure topographic change produced by a large flood event on the Rio Puerco, New Mexico

Mariela Perignon[1], Gregory E. Tucker[1] (presenter), Eleanor R. Griffin[2], Jonathan Friedman[3]

[1] Cooperative Institute for Research in Environmental Science (CIRES) and Department of Geological Sciences, University of Colorado, Boulder

[2] US Geological Survey, Boulder

[3] US Geological Survey, Fort Collins

The nature and pattern of vegetation on floodplains strongly affect the morphological changes that result from large floods by increasing drag and steering the flow through the landscape. Quantifying those changes is only possible through the use of high-resolution, multi-temporal topographic datasets. In 2003, herbicides were sprayed on a section of the Rio Puerco, New

Mexico, killing the tamarisk and sandbar willow on the floodplain and banks. A large flood in 2006 caused extensive erosion along the devegetated zone, widening the channel and eroding the floodplain. We use lidar differencing to quantify the topographic change that occurred along a 12-km reach of the arroyo immediately downstream of the sprayed section. We show that the pattern of deposition on the floodplain can be explained as the sum of two signals: the sediment concentration (which depends on the distance downstream of the sprayed reach), and local vegetation density. The presence of dense vegetation on the landscape, regardless of size or species, increases deposition by imparting a drag on the flow and reducing the boundary shear stress on the sediment surface. The spatial variability of sediment depth correlates with the size and spacing of stems: thick, widely spaced tamarisk trunks are associated with high variability in the depth of sedimentation, while dense but thin tamarisk and sandbar willow stems correlate with sheet-like deposits. Away from the influence of the sediment source, the erosion of the arroyo walls balances the deposition rate on the floodplain, resulting in widespread, uniform aggradation of the arroyo bottom.

A conceptual model of water-related impacts from bark beetle infestations

Evan Pugh[1] and Eric Gordon[2]

[1]Department of Geological Sciences, University of Colorado Boulder

[2]Western Water Assessment, Cooperative Institute for Research in Environmental Sciences, University of Colorado Boulder

Since 1996, an ongoing outbreak of bark beetles has caused widespread mortality across millions of acres of conifer forests in the Upper Colorado River Basin, especially in headwaters catchments with high rates of lodgepole pine mortality. Given that forests significantly influence streamflow compared to areas with other vegetation cover types, widespread tree death in watersheds can dramatically alter many ecohydrologic processes including transpiration, canopy solar transmission and snow interception, subcanopy wind regimes, soil infiltration, forest energy storage and snow surface albedo. Few studies have documented the effects of MPB infestations on hydrologic processes, and little is known about the overall direction and magnitude of changes in water yield and timing of runoff due to insect-induced tree death. In this presentation we will review and synthesize existing research and provide new results quantifying the effects of beetle infestations on canopy structure, snow interception and transmission to create a conceptual model of the hydrologic effects of MPB-induced lodgepole pine death during different stages of mortality. We will identify the primary hydrologic processes operating in living forest stands, stands in multiple stages of death and long-dead stands undergoing regeneration and estimate the direction of change in new water yield. This conceptual model can help water resource decision makers throughout the Intermountain West better understand the complex effects of bark beetle infestations on water supply availability.

Wildfire impacts on stream sedimentation: revisiting the Boulder Creek Burn in Little Granite Creek

Sandra Ryan and Kate Dwire

US Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado

The magnitude of hydrologic and sedimentologic changes observed in watersheds following wildfire depend largely on the severity of the burn, landscape susceptibility to erosion, and the timing and magnitude of storms following the fire. In this study of a burned watershed in northwestern Wyoming, USA (Boulder Creek burn in Little Granite Creek watershed), sedimentation impacts following a moderately sized fire (burned in 2000) were evaluated against sediment loads estimated for the period prior to burning and against a comparable control watershed. Early observations of suspended sediment yield showed substantially elevated loads (5x) the first year post-fire (2001), followed by less elevated loads in 2002 and 2003, signaling a return to baseline values by 3 years post-fire. More recent work (8 years post-fire) has shown elevated suspended sediment yields that are approximately double those predicted for the pre-burn range of flows. We tentatively attribute this to channel destabilization in the burned area due to the introduction of large wood from burned riparian areas and hillslopes. Repeat surveys indicated that the number of pieces of instream large wood were doubled and tripled in some reaches as burned trees began to decay and fall in to the channel. Observed channel changes associated with the introduction of new wood include: 1) increase in the size and number of jams; 2) deposition of coarse sediment within and behind jams; 3) channel avulsions; 4) erosion of banks and terraces where wood re-directed flow into the bank; and 5) multiple new sources of fine sediment due to bank instability. These results provide insight into longer-term geomorphic impacts of wildland fire that are associated with channel and bank instability in a burned riparian environment due, in part, to large wood dynamics.

River management under climate change: tools for planning under uncertainty

Joel Sholtes, M.A. and Brian Bledsoe, P.E., PhD

Civil and Environmental Engineering Department, Colorado State University
IWATER Fellow and PhD student, Associate Professor, respectively

Managers of civil infrastructure, water resources, and rivers in general all require tools for predicting river response to changing conditions caused by changing land-use, climate, or water use. A number of existing tools are at their disposal including conceptual and numerical hydrologic and geomorphic models, and empirical (statistical) relationships between flow and

channel dimensions and types. This work explores the capabilities and limitations of existing tools and approaches to predicting river response to climate change given the large uncertainties involved in predicting future precipitation and hydrologic regimes.

General circulation models (GCMs) and temporal and spatial downscaling methods provide uncertain climate and meteorological predictions of future temperature and, especially, precipitation regimes. Nevertheless, due to the societal need for water resources planning and development of new infrastructure, ensembles of down-scaled GCM outputs are used to predict changes in climatic central tendencies and extremes. In terms of predicting river response to changes in water and sediment fluxes, compounding uncertainties from climatic inputs through hydrologic and sediment transport modeling greatly limit this top-down approach.

We propose an inverse method to assess river response to climate change in which geomorphic thresholds and relative sensitivities of channel geometry to perturbations in driving variables are first identified and then compared with the range of predicted climatic and hydrologic changes. First we develop a mechanistic framework that links flow and sediment inputs and relative channel bed and bank stability to channel geometry. Our goal is to identify key geomorphic thresholds and which dependent channel variables are most sensitive to perturbations at various drainage scales. The magnitude of such conditions will then be compared to the envelope of predicted hydrologic and sediment input changes in the western U.S. to identify the setting, direction, and extent to which we may expect rivers to respond to climate change in the intermediate time frame (50-100 years). We will also test this model in the Yampa River basin, Colorado, one of few remaining western U.S. river basins with a largely un-curtailed snow-melt runoff hydrograph.

How to predict the start of runoff after wildfire

John A. Moody

U.S Geological Survey, National Research Program

Heat from wildfires is known to affect soil properties, and as a consequence the soil water infiltration and runoff from burned surfaces. This runoff often generates post-wildfire floods in channels downstream from burned basins. Research has focused on predicting the peak discharge of post-wildfire floods, but not on predicting the start of the post-wildfire floods relative to the rainfall. Soil-water content, rainfall intensity, and infiltration rates were measured on a hillslope burned by the 2010 Fourmile Canyon Fire west of Boulder, Colorado during cyclonic and convective rainstorms in the spring and summer of 2011. These data and measured soil physical properties were used as input into a numerical model of post-wildfire infiltration and runoff to provide insight into the post-wildfire runoff generation process.

Model calibration produced estimates of the saturated hydraulic conductivity, K_s (0.1 to 10 mm h^{-1}) that were relatively small. Model validation indicated that only a shallow layer of soil, h_w (the upper 1-2 cm), controlled runoff generation, and that the time-to-start of runoff (measured from the start of rainfall), t_p, was sensitive to the initial soil-water content, θ_0, at the start of rainfall. However, t_p did not correlate with the initial soil-water content for all 17 storms ($R^2 < 0.03$). Therefore, it was hypothesized that the shape of the rainfall hyetograph (storm profile) was important in determining t_p. Based on the small values of K_s and h_w a simple analytical model was developed to predict t_p by incorporating the soil saturation deficit (θ_s-θ_0) and a rainfall metric that estimates the initial rate of increase in the rainfall intensity (here called rainfall acceleration). This 'acceleration' model of t_p explained about 92% of the variance of t_p, and predicted values of t_p that were nearly identical to observed values. These results are from one burned site, but they strongly suggest that t_p in burned soils is probably controlled more by the storm profile and the initial soil saturation deficit than by soil hydraulic properties.

Geospatial tools for prefire planning and postfire analysis

Sam Litschert

Earth Systems Institute, Fort Collins, CO

Wildfire is a necessary and formative process that helps define forest structure and composition but frequently impacts hillslope stability, aquatic ecosystems, and water quality. Declining budgets, overlapping areas of interest, and increasing demands on planners and land mangers suggest that a shared, standardized, and scientific, yet inexpensive approach to prefire planning and postfire analysis is required. NetMap provides scientifically based tools to identify and prioritize three stages in postfire analysis by incorporating burn severity data with terrain, streams, and other geospatial data. First, on the hillslope, areas prone to surface erosion and mass wasting are identified, prioritized or quantified. Second, downstream propagation is calculated through routing or debris flows. Lastly, by locating habitat, and incorporating upstream and upslope impacts, we can identify postfire habitat and water quality impacts. The ability to locate areas with the worst impacts over large burned areas enables restoration treatments to proceed more swiftly and efficiently. Examples will be shown.

Experimental evaluation of the potential of wildfire affected soils and sediment to impact drinking water treatment processes

Amanda Schmidt[1], Jeffrey H. Writer[1, 2] and Deborah A. Martin[1]

[1]U.S. Geological Survey, Boulder

[2]Department of Civil, Environmental, and Architectural Engineering,
University of Colorado, Boulder

The water supply of many western communities originates from forested watersheds that may be affected by wildfire. Because wildfire size, severity, and the duration of the fire season have increased in recent decades, understanding the effects of wildfire on source water quality is a critical need for water resource managers. The chemistry of runoff from a burned watershed will likely be different following a wildfire, and consequently may affect drinking water treatability. In this study soils, ash, and sediment collected from burned watersheds were mixed with deionized water, and characteristics of the resulting water determined (pH, turbidity, dissolved organic carbon, and UV absorbance). Additionally, the response of wildfire impacted water samples to conventional drinking water treatment processes was evaluated using alum coagulation experiments. Results of this study indicate that ash and sediments from burned areas can release large amounts of dissolved organic carbon that is more difficult to remove by alum coagulation and thus may adversely impact drinking water treatment processes, whereas organic carbon released from burned soils was not substantially different from unburned soils.

Runoff and sediment transport following the High Park Fire: observations from the northern boundary, Hewlett Gulch Area

Eleanor Griffin[1] and Carol Champion[2]

[1]U.S. Geological Survey, Boulder, CO

[2]Livermore, CO

On Friday, July 6, 2012, heavy rains over the northern segment of the High Park Fire burn area caused flash flooding and debris flows in Hill Gulch and Falls Gulch that deposited sediment across Highway 14 near Poudre Park, Colorado, closing the road temporarily. The final report from the BAER team [High Park Fire Burn Area Emergency Response (BAER) Report, dated July 17, 2012, p. 8] stated that these flows were the result of "…a relatively small rainfall event…". However, observations of rainfall, runoff and sediment transport from a property nearby combined with 1-Day Observed Precipitation data provided by the National Weather Service (NWS) suggest rainfall over the northwest segment of the burn area that afternoon was substantial. Rainfall and subsequent runoff and sediment transport on July 6th were observed from a property near Hewlett Gulch, within the north boundary of the fire and 3.4 km north of the Poudre River at Poudre Park. At this site, heavy rainfall began about noon, and within a few minutes runoff was observed in a channel draining a 1.0 km^2 area that showed no evidence of having carried flow during the preceding 8 years. Heavy rainfall continued for about 2 hours in this area.

Following this event, we surveyed a 100-m long segment of this 2nd order, un-named ephemeral tributary of Gordon Creek, which flows through Hewlett Gulch to the Poudre River near Poudre Park. Most of the drainage area consists of steep, rocky hillslopes within the Roosevelt National Forest. We surveyed and excavated a cross section to obtain data used to compute minimum and maximum likely values of peak discharge during this event. Estimates of average flow depth in the channel during the peak runoff were a minimum of 0.20 m and maximum of 0.25 m. Average gradient of the nearly flat bed after the event was 0.0165. The fire

burned almost all vegetation within this reach, leaving relatively smooth channel banks. The initial flush of ash and fine sediment off of adjacent hillslopes early in the event resulted in a smooth, nearly flat channel bed. Size distribution was determined for a sample of the bed sediment.

We computed a range of possible peak discharges using the surveyed bed gradient, pre- and post-event channel shapes, and roughness estimated as that produced by saltating sediment. Average saltation height was computed for the median grain size of the bed material (2 mm). The results indicate the peak flow discharge was between 1.4 and 2.2 m^3/s (51 and 79 cfs). These values are 1.9 to 2.9 times the expected runoff given in the BAER report for a 10-year recurrence interval storm of 1 hour duration and 1.5 inches of total rainfall (70 cfs per square mile; 27 cfs per square km). These results suggest total rainfall in the vicinity of the Hewlett Gulch area on July 6th was closer to the maximum indicated over the northwestern segment of the burn area in the NWS observed precipitation data, which was on the order of 3 inches. This is greater than the mean total monthly precipitation for July, about 2.4 inches, and 41% of the average total summer precipitation, 7.32", measured at the nearest NWS Coop station, Buckhorn Mountain, 1E, Colorado (1988-2012). The rainfall event that caused flooding and debris flows in nearby Hill Gulch and Falls Gulch also may have been on the order of the maximum daily total summer rainfall reported by the Buckhorn Mountain Coop station, 2.98" measured on July 23, 1991.

Cache la Poudre River post-fire sediment and aquatic insect monitoring

Daniel W. Baker
Research Scientist
Department of Civil and Environmental Engineering
Colorado State University

Contributing Authors:
Brian Bledsoe – Colorado State University
Sara Rathburn – Colorado State University
LeRoy Poff – Colorado State University

The High Park and Hewlett Gulch wildfires of 2012 burned over 83,000 acres, 66,000 of those in the Cache La Poudre River watershed. The burned areas will further alter sediment loading and flow patterns in a river already confronted by flow extraction and adjacent development. The impacts of these changes fall across numerous management jurisdictions, affecting a broad gradient of socioeconomic and environmental interests and a diverse public. With this study, researchers from Colorado State University are collaborating with Colorado Parks and Wildlife and the City of Fort Collins to increase both the general knowledge of the impacts and to convey these impacts to the general public. Nine study sites on the Poudre River span from upstream of the burned area to I-25. Data collection at these sites will focus on the sediment and aquatic insect conditions of riffles over two years. We hypothesize varying impacts among the reaches within and below the canyon due to decreasing channel slope and increasing flow extraction. Our objectives include: (1) quantifying surface and bulk accumulation of fine sediment along a gradient of sediment input, flow alteration, and geomorphic setting, (2) linking the response of aquatic insects to fine sediment accumulation and (3) informing the public of the current and evolving post-fire conditions of the Cache La Poudre River ecosystem. An initial round of monitoring is nearly complete, and in this presentation we provide an overview to the project and preliminary findings.