ROCKY MOUNTAIN
HYDROLOGIC RESEARCH CENTER
63rd Annual Meeting

October 17, 2008

USDA Forest Service
Arapaho and Roosevelt National Forests Pawnee National Grassland
Fort Collins, CO

9:00-9:30 Registration and upload PowerPoint presentations

9:30-9:45 *Welcome and Introductory Remarks*
William M. Lewis, President RMHRC; Director, Center for Limnology, and Acting Director, Cooperative Institute for Research in Environmental Sciences, University of CO, Boulder

9:45-10:05 *Highlights of the 2008 Water Year in Colorado*
Nolan Doesken, Colorado State Climatologist and Senior Research Associate; Director, Fort Collins Weather Station

10:05-10:25 *Management Strategies for the Colorado River System*
Donald Frevert, Water and Environmental Resources Division, Bureau of Reclamation

10:25-10:45 *Nutrient Standards for Colorado Lakes*
William M. Lewis

10:45-11:00 *Break*

11:00-11:20 *Event-based Streamflow Simulation using the TREX Distribution Model and Ensemble Forecasts from the HMT-West Project*
Huiling Yuan, Cooperative Institute for Research in Environmental Sciences, University of CO and NOAA's Earth System Research Laboratory, Global Sciences Division, Boulder, CO

11:20-11:40 *Analysis of Streamflows and Sediment Movement Potential of Indian Creek, CA*
Robert T. Milhous, Hydrologist, Fort Collins, CO

11:40-12:00 *Collaboration on New Headgates Helps to Restore Winter Trout Habitat in St. Vrain Creek*
Glenn Patterson, St. Vrain-Left Hand Water Conservancy District

12:00-1:00 *Lunch*

1:00-1:20 *Effects of Watershed Subdivision, Resolution of Digital Elevation Model, and Resolution of Watershed Properties in the Colorado Urban Hydrograph Procedure*
Shawn Dankenbring, Department of Civil Engineering, University of Colorado, Denver and Felsburg Holt & Ullevig, Centennial, CO

1:20-1:40 *Dynamic Restructuring of Stream Invertebrate Communities Subject to a Hydrograph Truncated by Climate Change*
Marjorie L. Brooks, Department of Zoology and Physiology, University of Wyoming, Laramie, WY

1:40-2:00 *A New Twist on Mined Land Reclamation: How Natural Geologic Processes Control Water Quality in Colorado's Mineral Belt*
Travis S. Schmidt, Post-doctoral Research Ecologist, Mendenhall Fellow, USGS Mineral Resources Program, Denver, CO

2:00-2:20 *Collapse of Andean Empires and Ancient Climate Change*
Kenneth R. Wright, Chief Engineer, Wright Water Engineers, Inc. Denver, CO
Patricia K. Flood, Senior Engineer, Wright Water Engineers, Inc. Denver, CO

2:20-2:35 *Break*

2:35-2:55 *Road Dust Suppression*
Thomas G. Sanders, Department of Civil Engineering, Colorado State University, Fort Collins, CO

2:55-3:15 *Results and Recommendations for the Automation of Snow Measurements in the United States*
Wendy Ryan, Colorado Climate Center, Department of Atmospheric Science, Colorado State University, Fort Collins, Co

3:15-3:35 *Precipitation and Runoff in Mountain Watersheds*
Eric Richer, Graduate Student, Watershed Science program, Department of Forest, Rangeland, and Watershed Stewardship Warner College of Natural Resources, Colorado State University, Fort Collins, CO

3:35-3:45 *Closing remarks*
William M. Lewis

3:45 Open Meeting Adjourns

4:00-5:00 Board Meeting

5:00 *Adjourn*

ROCKY MOUNTAIN HYDROLOGIC RESEARCH CENTER

63rd ANNUAL MEETING

OCTOBER 17 2008
9:00 am to 5:00 pm

CALL FOR ABSTRACTS

http://RMHRC.colorado.edu

PURPOSE:

This meeting provides an opportunity for scientists working in the Rocky Mountain region to discuss their research in a relaxed, yet scientifically stimulating atmosphere. The meeting encourages interdisciplinary communication among professionals and students in the fields of hydrology, geomorphology, aquatic ecology and water resources.

TOPICS FOR THE MEETING:

- Precipitation and Runoff in Mountain Watersheds
- Climate and Climate Change in the Western United States
- Floods in Urban Environments
- Paleohydrology and Paleoclimatology
- Hydraulics and Sediment Transport in Rivers
- Chemistry of Natural Waters
- Aquatic and Riparian Ecology
- Water Resources and Environmental Policy

LOCATION

USDA Forest Service
Arapaho & Roosevelt National Forests Pawnee National Grassland
Fort Collins, CO

RMHRC 2008 abstracts

Highlights of the 2008 Water Year in Colorado

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The 2008 Water Year was the first year since the mid 1990s with cooler than average temperature during both winter and spring. Other than one major storm in mid October, the first two months of the 2008 water year were warmer and drier than average. Stormy winter weather arrived in December, and significant mountain snow accumulation began. Several snow blitzes over southwest Colorado left such deep snow that spring flooding was anticipated. Late winter snows tapered off over southern Colorado but continued over the northern mountains. The combination of cool spring weather and deeper snow produced high stream levels all through June. Spring storms were relatively few along the Front Range, but high elevation snows produced adequate runoff to fill most reservoirs and maintain good summer streamflow. July was hotter than average – which has been the rule in recent years. Drought and fire concerns increased, especially over the eastern half of Colorado. But wet and cooler weather in August reduced these concerns. For the year as a whole, precipitation ended up above average over most mountain areas and near to below average east of the mountains. Examples and data summaries will be presented. The role of the Community Collaborative Rain, Hail and Snow network and the Colorado Agricultural Meteorological Network in climate monitoring in Colorado will be described.

Management Strategies for the Colorado River System

Donald Frevert[1], Jose Salas[2], Jim Prairie[3], Jeff Lukas[4] and Terrance Fulp[5]

An interdisciplinary technical work group, convened in 2004 has approached the question of drought and flood frequency on the Colorado River basin using a variety of approaches. These approaches include both parametric and non-parametric stochastic hydrology as well as independent tree ring analyses.

Products from this group were utilized in formulating the Colorado River Shortage Strategy Environmental Impact Statement and Coordinated Operations Guidelines which were released by the Secretary of the Interior in December, 2007.

Results indicate that the recent drought, which began in 1999, is probably not the worst that has been seen in the past 500 years.

1)Hydraulic Engineer, Bureau of Reclamation, Technical Service Center, Lakewood, CO
2)Professor of Civil Engineering, Colorado State University, Fort Collins, CO
3)Hydraulic Engineer, Bureau of Reclamation, Upper Colorado Region, Boulder, CO
4)Professional Scientist, Institute of Arctic and Alpine Research, University of Colorado, Boulder, CO
5)Assistant Regional Director, Bureau of Reclamation, Lower Colorado Region, Boulder City, NV.

Event-based Streamflow Simulation using the TREX Distributed Model and Ensemble Forecasts from the HMT-west Project

Huiling Yuan[1, 2, *], Jonathan J. Gourley[3], Paul J. Schultz[2], John A. McGinley[2], Zac Flamig[3], and Christopher J. Anderson[4]

Short-range quantitative precipitation forecasts (QPF) not only provide useful weather information, they also add value to river forecasts. This study investigates the usefulness of high-resolution QPF in simulating streamflow over the North Fork of the American River Basin in Northern California through a spatially distributed hydrologic model. Event-based streamflow simulation is conducted for selected heavy rainfall events using the Two-Dimensional Runoff Erosion and Export (TREX) model. During the Hydrometeorological Testbed (HMT)-West campaign, ensemble forecasts at 3-km resolution were implemented for three winters (2005/06, 2006/07, and 2007/08) in the Northern California region, including four mesoscale model configurations based on the Weather Research and Forecasting (WRF) model. All models were diabatically initialized by the local analysis and prediction system (LAPS), which greatly reduces the "spin-up" problem for the 0-6-h QPF. The 0-6h ensemble-mean QPF and the 6-h, Stage IV quantitative precipitation estimation product (QPE) are disaggregated to hourly rainfall at 150 x 150 m resolution and used as independent inputs to the TREX model. The TREX parameters are calibrated for one heavy rainfall event using the QPF and QPE products and applied to the rest of the events for validation. Statistical scores are computed based on the timing of peak discharge, magnitude of peak discharge, and integrated discharge volume of the simulated discharge compared to the USGS observations. For some events, the simulation results using QPF inputs show increased value compared to the simulations using QPE inputs. The TREX model also shows deficiencies in simulating snowmelt events.

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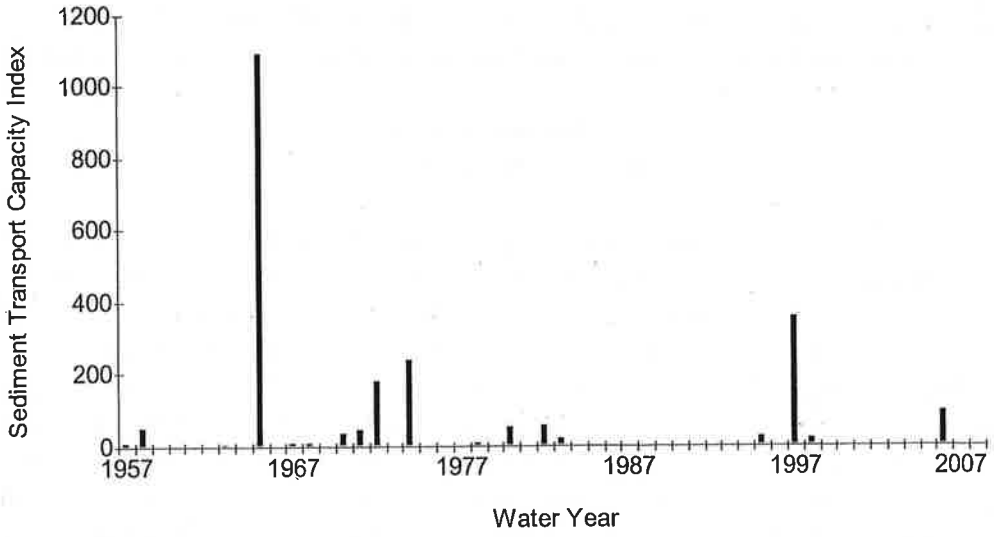
Analysis of streamflows and sediment movement potential of Indian Creek, California

Robert T Milhous
Hydrologist
Fort Collins, Colorado

Indian Creek is a tributary of the Klamath River that joins the Klamath River at Happy Camp, California. Salmon spawn in Indian Creek. The object of this paper is show how to determine the years scour of the spawning areas (redds) may occur and be important in the reproductive process. The period of record of daily streamflow for a USGS gage on the creek is from December 1956 to current year. The substrate was sampled near the gage. The overall d50 at the cross section just above the gage is 89 mm compared to 59 mm in a transport zone covering about 50% of the cross section. An index to the ability of the river to transport sediment has been used to obtain some idea of the sediment movement potential. The index is:

$$STCI = \sum_{i=1,n} \frac{(Q(i) - Qcrt)Q(i)}{Qref^2}$$

where STCI is the sediment transport capacity index for the n-days of the summation, Q(i) is the daily discharge, and Qcrt is the critical discharge. The STCI is for a water year from 1 October – 30 September (365 or 366 days). Qref is a reference discharge and was 1000 ft^3/s. A critical discharge for redd scour was determined to be 4650 ft^3/s. The STCI then becomes an index to the potential scour of redds. The annual time series of the index is presented below:



There has been some potential for scour in 18 of the past 52 years but only five have had a major scour potential.

Collaboration on New Headgates Helps to Restore Winter Trout Habitat in St. Vrain Creek

Glenn Patterson
St. Vrain-Left Hand Water Conservancy District

Trout are a native species in St. Vrain Creek in the reach between Lyons and Longmont, where the mountain creek makes its transition to a plains stream. A critical limiting factor for trout habitat in this reach is low winter streamflow. Ditch companies with headgates in this reach have water rights for storage that allow them to divert creek water during the winter to fill reservoirs. During periods of cold and dry weather when streamflow is diminished, these diversions for storage may dry up the creek just below their points of diversion, resulting in a streambed with stagnant pools and no flow.

A 1992 water leasing agreement between the St. Vrain Corridor Committee and the City of Longmont provides for the City to release water from Ralph Price Reservoir in Button Rock Preserve into North St. Vrain Creek to help maintain sufficient instream flow for trout. A way was needed, however, for these small instream flows to make it past the ditch headgates without being diverted. In order to provide the precision metering and control needed to separate the instream-flow releases from the legal diversions, in 2008 the Corridor Committee, working with the City of Longmont, Boulder County, and the St. Vrain-Left Hand Water Conservancy District, installed a special flume gate at the diversion point for the Oligarchy Ditch. The goal is to install two additional flume gates at two other key diversion points for storage decrees. The result is expected to restore sufficient winter instream flow to maintain the trout fishery.

Effects of Watershed Subdivision, Resolution of Digital Elevation Model, and Resolution of Watershed Properties in the Colorado Urban Hydrograph Procedure

Shawn C. Dankenbring, PE[1,2]
David C. Mays, PE, PhD[1]

When planning highways, engineers and designers use hydrologic analysis to design a crossing to pass the design storm without inundating or impacting property owners or risking the roadway being washed out. Within the profession, there is an ongoing discussion about what is the optimal procedure to: (1) subdivide the watershed into smaller sub-catchments, (2) select a digital elevation model (DEM) with appropriate vertical resolution, and (3) select the area over which watershed properties, such as soil type and percent imperviousness, are averaged. To examine these questions, a series of hydrologic analyses were performed on the East Toll Gate Creek Watershed, Arapahoe County, Colorado. The Colorado Urban Hydrograph Procedure (CUHP) was used to generate hydrographs for each watershed and sub-catchment. The Environmental Protection Agency's Storm Water Management Model was used to route the hydrographs when the watershed was subdivided. CUHP inputs were derived from DEM data available from the U.S. Geological Survey, and from Land Use data available from Arapahoe County, with spatial analysis by the geographic information system (GIS)

software package Arc Hydro. To evaluate the effect of watershed subdivision, the watershed was subdivided into 2, 3, 4, 5, and 6 sub-catchments, using 10 m (33 ft) DEM and constant soil type and percent imperviousness. The average output flow was 1,814 cubic feet per second (cfs) for the six analyses, with all results within ±4%. The next step in the study was to determine if using different DEMs would affect the results. Results using 10 m (33 ft) and 30 m (98 ft) DEMs were compared, using a single catchment and constant soil type and percent imperviousness. The overall results were similar, with the average outflow being 1,810 cfs, with all results within ±4%. The last step was to evaluate the effect of allowing watershed properties to vary for each sub-catchment. The results are given for the six sub-catchments using the 10 m (33 ft) DEM. Allowing the imperviousness to vary resulted in higher output, contrary to what is normally expected when higher imperviousness occurs in the upper part of the watershed. The average output for these analyses was 1,899 cfs, with all results within ±2%. Therefore, for each variable examined, the predicted peak flow was always within a few percent of the peak flow predicted by the simplest model. Future work would be required to generalize these results beyond this particular case study.

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A New Twist on Mined Land Reclamation: How Natural Geologic Processes Control Water Quality in Colorado's Mineral Belt.

Schmidt T.S., Church, S.E., Clements W.H., Mitchell K., Fey D.L., Wanty R.B., Verplanck P. L., San Juan, C.A., and Adams, M.

Recent geochemical surveys of mountain streams in Colorado suggest that up to 25% are impaired by elevated trace-metals. Fully 55% of the central Colorado Rock Mountains are owned by the Federal government. Due to increasing pressures from development in mountain communities, the Federal government in interested in improving these lands to create better recreational opportunities and to improve water quality to mountain and Front Range communities. We surveyed 150 mined, unmined, and mineralized watersheds to determine the extent these streams are impaired by naturally occurring mineralized rock and that influenced by mining. Our sampling design targeted small catchments underlain by a monolithic rock type allowing for the development of biological and geochemical baselines based on rock type. Watershed mine densities range from unmined to as high as 224 mine openings in a catchment containing just over 800,000 cubic yards of tailings. We found that unmined catchments hydrothermally altered or mineralized can have poor sediment and water quality resulting in depressed aquatic community diversity and abundance. While in mined catchments the number of mines (greater than 10) and volume of tailings piles (greater than 1,000 cubic yards) also resulted in significant declines in aquatic community diversity and abundance. Surprisingly, when tailings volumes exceeded 10,000 cubic yards, significant improvement was observed in the aquatic communities. Those watersheds with greater than 10,000 cubic yards of tailings were found to be aggregate mines from carbonate rock formations, or derived from rocks which were propolyticly altered. The sediment and

water quality in these catchments were of higher quality than that expected by tailing volume along. These results suggest that the presence or absence of a mine in the watershed makes for a poor predictor of the aquatic community health, while mining districts can have profound negative effects on aquatic ecosystems. However, the type of rock from which these mining districts are found can also strongly attenuate the effect the mining district has on the stream.

Collapse of Andean Empires and Ancient Climate Change

Kenneth R. Wright, P.E., and
Patricia K. Flood, P.E.

Andean people have an extraordinary heritage of energetic civilizations extending back to the Initial Period some 3,800 years ago. As the modern Andean people have entered the 21st Century, their examination of the fortunes of ancient empires along with records of past concurrent climatic changes and extremes can provide useful natural resource planning tools. The vagaries of nature had an effect on the great pre-Columbian empires, as much as modern Andean societies. The Pacific coastlands and the higher elevation plains of the Andes are subject to wide variation in climate due to the El Niño/Southern Oscillation (ENSO) phenomena, and periods of plentiful water can be replaced with drought depending upon changing ocean temperatures.

Ancient Andean civilizations have been studied, their temples and cities excavated, their works of art collected and the multitudes of ruins analyzed. Previously, the causes of the demise of many of the empires were subject to scholarly judgment based upon the physical evidence found in and amongst the excavated ruins. Research was not based on written scrolls or tablets because the ancient Andean civilizations had no written language; even the later Inca Empire was administered without one.

During the last several decades, dedicated physical scientists began drilling ice caps and logging tree rings. Glaciologists, meteorologists, geologists, marine scientists, oceanographers, and hydrogeologists probed the great ice caps and glaciers of the Andes, studied the climate variations and floodplain deposits, determined the Pacific Ocean temperatures, and analyzed rainfall runoff relationships. By coring ice caps, a "record" of Andean precipitation, temperatures, pollen and dust accumulation was retrieved—not just a few hundred years of climate data, but some 1,500 years of such data. This information was then correlated with "on-the-ground" findings to piece together what happened in ancient times.

Considerable insight into the environmental impacts on several ancient Andean civilizations has been gained by the scientific community throughout many decades of study. These include the Tiwanaku Empire centered near the south shore of Lake Titicaca; the Huari Empire that lay north of that of the Tiwanaku; the Moche Kingdom of northern coastal Peru, and the Inca Empire which encompassed nearly all of the Andean portion of South America. The environmental stresses faced by the Tiwanaku and Huari Empires are examined herein as examples of the consequences of underestimating environmental risks.

Road Dust Suppressants Research Results

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Road dust suppression has two significant benefits: 1) decreasing a major source of air pollution, 2) prolonging the life of a dirt road. It is well known that a large portion of the particulates in the air are related to dirt roads. And it is known that the use of chemical dust suppressants or even just regular watering increases the time between road maintenance and aggregate replacement. In fact, this research has shown that the use of dust suppressants will decrease aggregate loss between 2-3 times of treated dirt roads versus untreated dirt roads.

The purpose of this paper is to discuss the research results from Colorado State University of the effects of the use of chemical dust suppressants on dirt road life and fugitive dust emissions. The dust suppressants tested were lignonsulfanate, magnesium chloride, calcium chloride and calcium chloride special. During the initial stages of the research it was determined that the use of the conventional bucket surveys would not be sufficient and could not generate enough quantitative data for the research to find the most effective dust suppressant. As a result, the Colorado State University Dustometer and a field test protocol were developed to generate a large amount of data to determine which dust suppressant is most effective for the given conditions. The road test sections were one mile, the vehicle, driver and vehicle speeds remained unchanged throughout the research. In another test, the Dustometer was used to quantitatively assess the impact of the vehicle velocity on dust emissions. And as part of the research the tons of aggregate loss per vehicle per mile per year was quantified as well. While the untreated road lost 2.59 tons/mi/ADT/yr, the road treated with lignonsulfanate lost 1.01, $CaCl_2$, 1.49 and $MgCl_2$, 1.04. In terms of dust generation, the lignonsulfanate was the most effective for about three months but deteriorated rapidly. In the economic analysis for the given cost of aggregate and the existing ambient conditions, $MgCl_2$ was the best choice when the ADT was greater than 120. The relationship between dust generation and vehicle velocity was also established. Increasing the vehicle speed from 30 mph to 50 mph almost doubled the amount of dust production and although it appears to be linear, visual observations in the field indicate it is more probably nonlinear and quite possibly exponential. What is not known which future research could answer is the effect of vehicle weight and tire dimensions on dust production and the relationship between dust production and aggregate loss. More fundamentally there are no data that the suggested application rates and field procedures recommended by the suppressants distributors are optimal.

Although the Dustometer was developed specifically for this research replacing and improving upon bucket surveys and other measurement techniques, it may, in fact, be better suited and more applicable as a management tool to generate data on site prior to road dust management decisions.

Snow Cover Depletion Characteristics to Support Flow Forecasting for the Cache la Poudre River, Colorado

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The Cache la Poudre River in northeastern Colorado is a source of water for many agricultural, municipal, and industrial users. The river is modified by an extensive network of diversions and impoundments to meet regional water needs. Most runoff in the basin is generated from snowmelt, but SNOTEL measurements are located only at select high elevation points. For this study we analyzed snow covered area (SCA) depletion characteristics to see if they could improve snowmelt runoff prediction. Moderate Resolution Imaging Spectroradiometer (MODIS) 8-day snow-cover products were obtained for the Cache la Poudre basin from 2000 to 2006 for March through June of each year. Snow cover depletion was investigated in spatial subsets of the basin, including sub-basins and elevation bands. Regression analyses compare the 8-day SCA images to 8-day average stream flow at the USGS canyon mouth gauge (the forecasting location). Results from regression analyses show a wide range of relationships between SCA and streamflow ($0.03<R^2<0.92$), mostly as a result of high inter-annual variability in the flow regime. SCA image impairment from cloud cover also impacted results in some years. For sub-basins, the strongest correlations between SCA and streamflow were for high elevation sub-basins ($0.60<R^2<0.92$), whereas for elevation bands, the strongest correlations were for a mid-elevation band, 2680-3042 m ($0.60<R^2<0.92$). The poorest relationships between SCA and streamflow occurred for low elevation bands, 1591-1953 m and 1954-2315 m, and very high elevation bands, 3406-3768 m and 3769-4131 m. The strong relationship between SCA and discharge at middle elevations suggests that runoff prediction can be improved by monitoring snow cover within these areas. We are analyzing these relationships between discharge and SCA to determine an appropriate network of sub-elements for a quasi-distributed snowmelt runoff model. Results suggest this relationship is stronger for a network of sub-basins than for elevation bands or the basin as a whole.

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