70th Rocky Mountain Hydrologic Research Center Annual Meeting
October, 23, 2015
Tivoli 440
(info: http://www.ahec.edu/shared-campus-services-resources/tivoli-student-union/)
Auraria Campus
Denver, Colorado

9-10am	**Registration and refreshments**
10-10:20	**Welcome and Address from President Glenn Patterson**
10:20 – 10:45	**A Review of the 2015 Water Year in Colorado,** Zach Schwalbe
10:45 – 11:10	**At the Nexus of Fire, Water and Society,** Deborah A. Martin
11:10-11:35	**Complex Sediment Response in a Basin Disturbed by Wildfire,** John A. Moody
11:35 – 12:00	**Fountain Creek Sediment Load Changes,** Kenneth Wright
12:00-1:00	**Lunch**, Tivoli Food Court
1:00-1:25	**Using the Transdisciplinary Approach to Remove Plastic Microbeads from Colorado Rivers,** Greg Cronin
1:25-1:50	**Transport and Export of Coarse Particulate Organic Matter (CPOM) in Steep Streams,** Kristin Bunte
1:50 – 2:15	**Effect of acid mine drainage on the abundance and diversity of freshwater nitrifying microbes,** Annika Mosier
2:15-2:40	**A landscape-based approach to assess endocrine disruption in fish in the Shenandoah River,** Vajda, A.M
2:40-2:45	**Closing remarks**
3:00-5:00	**Board of Trustees Meeting**

A Review of the 2015 Water Year in Colorado

Zach Schwalbe (presenter), Noah Newman, Nolan Doesken

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After the September floods of 2013, most of Colorado enjoyed a good year in 2014 with generally good to excellent water supplies and moderate temperatures. Water year 2015 (October 1, 2014 - September 30, 2015) got off to a good start with fairly generous autumn precipitation. But as winter progressed mountain snowpack accumulation lagged behind normal expectations. By early April. water supply concerns were growing quickly, especially over the Upper Colorado River Basin. Unseasonable warm early spring temperatures in March and April kick started earlier than average snowmelt. Then came a major change in weather patters and storm tracks. From the 16th of April into early June, major slow-moving storms crossed Colorado almost every week. By May and June, drought concerns shifted abruptly to flooding. Wet weather continued into midsummer but then gave way to a very dry finish to the growing season for much of the state. The South Platte and Arkansas River basins ended up with much above average streamflow for the year while the Colorado and Rio Grande, which had been predicted back in April to have very low streamflow, both ended up with near average runoff for the year. Evapotranspiration rates were very low much of the late spring andsummer during the cloudy, wet late spring, but were returning to near normal later in the growing season thanks to a warm and dry finish in August and September.. Maps and graphs will be presented to tell the story of the 2915 water year and it's "Miracle May" -- wettest statewide in recorded history.

At the Nexus of Fire, Water and Society

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In 2015 the World Economic Forum declared that water crises (significant declines in water quality and quantity) are the greatest risks facing society. Water supplies are derived from several land cover types that are vulnerable to fire, but on a global basis, the highest percentage of water delivered to the world's largest cities and numerous smaller communities comes from forested landscapes. Fire alters the hydrologic functions of forested catchments, including water interception, storage and discharge, and thus the timing and magnitude of water, sediment and chemical constituent export. Two major themes emerge from research on burned catchments. First, in response to intense rain, burned catchments usually have higher peak flows compared to unburned catchments. Second, the altered hydrologic response of burned catchments leads to increased concentrations and loads of constituents dissolved in the water or associated with sediments. These changes can persist for decades. Post-fire studies have measured elevated concentrations and changes in the timing of the transport of carbon, nitrogen and other nutrients, sediment, heavy metals, and organic compounds like polycyclic aromatic hydrocarbons (PAH's). These constituents have the potential to affect the treatment of water for human consumption and can impact the quality of water stored in lakes and reservoirs. Efforts already exist in several parts of the globe to protect forested landscapes from disturbance because of their important role in providing ecosystem services and ability to act as "natural infrastructure" to deliver water-related services with minimal need for the construction of engineered infrastructure. However, we currently lack comprehensive tools to consider the effects of fire in planning, protecting and creating resilience in our water supplies. Clearly, the need to understand the nexus of fire, water and society has become more pressing in the face of mega-fires, weather extremes and climate change.

Complex Sediment Response in a Basin Disturbed by Wildfire

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The 1996 Buffalo Creek wildfire burned 79% of the Spring Creek basin (2680 ha) located in the Colorado Front Range Mountain southwest of Denver, Colorado. This disturbance was followed by a ~100-year, 1-hr rain storm resulting in an extreme flood with an estimated peak discharge of 510 $m^3 s^{-1}$ and water depths exceeding 2 m in the main channel (~27 m wide). This extreme flood generally eroded low-order basins (1-5) and deposited 1-2 meters (~1.1 million m^3) of sediment in the main channel of Spring Creek (order 6) creating a nearly planar surface with an average slope of about 0.04 and composed of predominantly 2-4 mm particles. Cross sections were established in 1997 to monitor sediment erosion, transport and deposition at 18 locations spaced 50-100 m apart along a study reach extending 1500 m upstream from the mouth of Spring Creek. These cross sections have been monitored for18 years, and a complex response has been documented in response to a succession of winter, snowmelt, summer convective-storm, and inter-storm runoff.

Annual rainfall generally decreased from ~300 mm in 1996 to ~105 mm during the period 2002-2008 when there was a regional drought, and then gradually increased to ~300 mm in 2014. The first extreme flood (July 1996) was followed by 10 major floods (discharge > 1 $m^3 s^{-1}$) in response to summer convective storms from 1997 through 2000 and numerous minor floods (<1 $m^3 s^{-1}$). In general, there was a cycle of channel incision between major floods followed by re-leveling of channel sediment during each major flood. After about 2000, the riparian vegetation (primarily willows, *Salix sp*.) had recovered sufficiently to attenuate any flood peaks, which were probably initially lower after 2000 because of the recovery of soil properties and the vegetation on surrounding hillslopes.

Several depositional processes were observed to create distinct sediment deposits. First, were braided deposits, which formed as multiple threads of shallow water transported sediment as bed load and deposited it as levees. These levees caused the flow to change directions, thus leaving the deposits to accumulate. Second, were "percolation" deposits created as surface water percolated into the bed, stranding bed-load particles. This process created an extensive "in-channel fan", which existed for several years and was completely covered by ice in the winter. Third, were "winter deposits" that formed when the sand and gravel sediment comprising the "banks" was frozen, which made the bank sediment cohesive. Flowing water was then only able to erode narrow slot-like channels; and at times when the water exceeded the height of the channel "banks" it deposited sediment on the adjacent surface and refroze. Fourth, were dry-ravel deposits of colluvial sediment into the main channel of Spring Creek. This process was also observed in the winter as a freeze-thaw process on south-facing hillslopes. Thawing of these hillslopes in the morning light released sediment that rolled downslope. Fifth, were "fall out" deposits created when suspended sediment during a major flood was re-deposited during the falling limb of the hydrograph as the shear stress rapidly decreased with decreasing water depth and in some cases with decreasing slope. Finally, the sixth type of deposit was "vegetation trapping" deposits caused by the re-growth of primarily multiple-stemmed willows along the channel starting about seven years after the wildfire.

Initially, the study reach of the Spring Creek channel was braided and filled the valley with the narrowest cross section (~10 m) farthest upstream from the mouth and the widest cross section at the mouth (~50 m). Superimposed on this general trend was additional spatial variability in the form of local minimum and maximum widths that also varied with time. Similarly, while the average bed slope over a longitudinal distance of 1500 m was 0.04, it initially varied spatially from ~0.037 at the mouth of Spring Creek to a local maximum of ~0.047 at 341 m (upstream from the mouth) to a local minimum of 0.032 at 905 m to a value of ~0.05 at 1500 m. This spatial variation in slope affected the sediment transport. Additionally, bed slope varied with time due to sediment erosion and deposition such that the overall maximum bed slope was 0.056 and the overall minimum was 0.024. The complex response of this disturbed system was caused by different sequences of depositional processes at each cross section, which were functions of the spatial and temporal variability of widths, spatial and temporal variability of local bed slope, and the sequence of runoff processes.

Fountain Creek Sediment Load Changes

Kenneth Wright, P.E. and Ian Paton, P.E.
Wright Water Engineers, Inc.

Urbanization, impervious area increase and imported water in the Fountain Creek watershed in the Arkansas River basin in southeastern Colorado have resulted in a marked increase in storm runoff and sediment load to the channel of Fountain Creek between Colorado Springs and Pueblo. Analyses of hydrologic data demonstrate that subsequent to the 1970-1980 period of increased growth in population, the average rate of flow and the sediment yield have increased in Fountain Creek in a manner consistent with urban development. This has resulted in substantial aggradation and bank erosion in the Fountain Creek channel which has created adverse impacts in the downstream Pueblo County. Detailed studies of the hydrology of Fountain Creek by the U.S. Army Corps of Engineers, the U.S. Bureau of Reclamation, the U.S. Geological Survey and private contractors describe the adverse impacts and potential solutions. It has been concluded that a solution to the continuing hydrologic problem will require basin-wide watershed management, substantial drainage infrastructure improvements in Colorado Springs and soil stewardship to achieve a sustainable flood and sediment regime in Fountain Creek.

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Using the Transdisciplinary Approach to
Remove Plastic Microbeads from Colorado Rivers

Greg Cronin (presenter), University of Colorado Denver, gregory.cronin@ucdenver.edu
Marchetta, T, Shelley, C., and McKiernan, M., Channel 7 News

Transdisciplinary scholarship is a powerful approach to address major problems facing society. Sometimes these problems, such as global climate change, are called wicked, or super wicked. The scientific method is a great approach for addressing problems that can be stated as a hypothesis, but it is not very applicable to wicked or super wicked problems. The transdisciplinary approach integrates the natural sciences, social sciences, arts, and more by forming partnerships among academics, community leaders, and stakeholders.

Plastic microbeads are put in personal care products such as toothpaste and facial scrubs. Obviously these products get washed down the sink after customers use them. Their small size and neutral density result in the microbeads remaining uncaptured by standard wastewater treatment processes. Therefore, many plastic microbeads make their way into streams. The best way to keep plastic microbeads from polluting surface water is to remove them from products that get intentionally discarded into wastewater.

Water samples taken downstream from Metro Wastewater Reclamation District contained small particles made of polystyrene. Interviews demonstrated that product users were unaware of plastic microbeads in their personal care products, and a desire to have the plastic removed from the products, or replaced with safer, biodegradable ingredients. A dental hygienist reported finding the plastic microbeads lodged in the gums of patients. No stakeholders that were interviewed indicated that they wanted the plastic microbeads to remain in products. Manufacturers indicated that they had plans to voluntarily remove the plastic microbeads from products. They did not indicate why plastic microbeads were added to products to being with. Policy makers declined an invitation to be interviewed. Results of the study were communicated to the community on Denver television Channel 7.

Representative Dianne Primavera of Broomfield sponsored a bill to remove plastic microbeads from products in the State of Colorado. Governor Hickenlooper signed HB15-1144 into law on March 26, 2015, making Colorado the fourth state in the US to ban such products. There is discussion of Federal legislation to ban the products across the nation.

There is a need for the transdisciplinary approach to be rewarded in higher education. This significant scholarly accomplishment by the applied ecologist in the Department of Integrative Biology was not rewarded during annual merit review. Though a clear accomplishment of the scholarship of discovery and scholarship of application, the Department Chair counted it as service.

Transport and Export of Coarse Particulate Organic Matter (CPOM) in Steep Streams

Kristin Bunte, Colorado State University, kbunte@engr.colostate.edu; Kurt W. Swingle, Environmental Scientist, Boulder, CO, kskb@ix.netcom.com; Jens M. Turowski, German Research Centre for Geosciences, jens.turowski@gfz-potsdam.de; Steven R. Abt, Colorado State University, sabt@engr.colostate. edu; Daniel A. Cenderelli, USDA Forest Service, National Stream and Aquatic Ecology Center, dcenderelli@fs.fed.us.

Coarse particulate organic material >1 mm (CPOM) comprising mainly leaves, needles, cones, twigs, and decaying wood pieces is an energy source in headwater ecosystems, and CPOM transport of is one form of watershed carbon export. However, sampling methods for instantaneous CPOM transport rates and annual loads are not well developed, and hence not much is known about annual CPOM export from high energy, forested mountain streams.

CPOM transport samples were collected over one-month snowmelt highflow seasons in two high-elevation, subalpine, Rocky Mountains streams with snowmelt regimes as well as in a montane torrent in the Swiss Pre-Alps with a pluvio-nival regime. Basin areas ranged from 0.9 to 13 km^2. Bedload traps and automated hanging baskets installed at an overfall, developed for sampling gravel bedload, proved suitable for sampling CPOM transport.

Bedload traps with 0.3 by 0.2 m openings are typically deployed for an hour at a time during wadeable flows, collect samples back-to-back, and may trap volumes of up to 20 liters in the attached 1.4 m long nets. At the Swiss site, hanging baskets with a 1 m^3 volume are deployed at an overfall in unwadeable flows, and bedload traps in wadeable flows. When flow overtopped bedload traps, CPOM transport rates were adjusted to estimate and add the unsampled CPOM portion traveling higher in the water column; when nets overfilled, CPOM transport rate were adjusted for the reduction in captured transport.

CPOM transport rates were well related to flow in consecutive samples but showed pronounced hysteresis over diurnal fluctuations of flow, between consecutive days, and over the rising and falling limbs of the high-flow season. Hysteresis effects require intensive sampling and use of separate rating curves for all rising and falling limbs in order to compute annual CPOM load. Annual CPOM export for the two Rocky Mountain streams was 2.7 and 4 kg/ha/year, but both streams exported 6.5 and 6.6 kg/ha/year per forested portion of the watershed.

Instantaneous CPOM transport rates are moderately well related to discharge, unit discharge, and unit stream power within individual streams. However, all three streams follow a similar transport relation of CPOM only with unit discharge, suggesting that unit discharge could be suitable to predict CPOM transport rates in steep streams.

Effect of acid mine drainage on the abundance and diversity of freshwater nitrifying microbes

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Extremely acidic and metal-rich acid mine drainage (AMD) waters can have severe toxicological effects on aquatic ecosystems. AMD was shown to completely halt nitrification, which plays an important role in transferring nitrogen to higher organisms and in mitigating nitrogen pollution. We are evaluating whether AMD differentially impacts three groups of microorganisms involved in nitrification: ammonia-oxidizing archaea (AOA), ammonia–oxidizing bacteria (AOB), and nitrite–oxidizing bacteria (NOB). Sediment and water were collected from AMD-impacted aquatic sites during June and August 2013 in the Iron Springs Mining District (Ophir, Colorado). Many of the sites were characterized by low pH (<5), low dissolved oxygen concentrations (<6 mg/L), and high metal concentrations. Community sequencing based on the 16S rRNA gene revealed the presence of AOA (*Nitrososphaera* and *Nitrosopumilus*), AOB (*Nitrosomonas*), and NOB (*Nitrospira*) at multiple AMD-impacted sites. The overall abundance of AOA, AOB and NOB were examined using quantitative PCR (qPCR) amplification of the *amoA* and *nxrB* functional genes. Bacterial *amoA* and *Nitrobacter nxrB* genes were not PCR amplifiable, though additional primer sets are still being evaluated. Archaeal *amoA* gene copy numbers ranged from 24-2.9×10^4 copies/µl of sediment DNA. *Nitrospira nxrB* gene copy numbers ranged from 80-3.5×10^5 copies/µl of sediment DNA. Overall gene abundance was somewhat correlated with dissolved copper concentrations for both groups (R^2=0.6 for AOA *amoA* and R^2=0.7 for *Nitrospira nxrB*). There were no significant correlation between gene abundance and other environmental parameters (e.g., pH, temperature, conductivity, dissolved oxygen, or other metals). These findings extend our understanding of the relationship between AMD and freshwater nitrifying microbes and provide a platform for further research.

A landscape-based approach to assess endocrine disruption in fish in the Shenandoah River

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The elucidation of cause and effect relationships between putative endocrine disrupting chemicals and adverse outcomes in wildlife is confounded by the complexity of mixtures and temporal variation present in ecosystems. We have developed a landscape-based model in an attempt to link complex chemical mixtures to adverse outcomes across multiple levels of biological organization. We hypothesize that landuse patterning in a watershed will correlate with the chemical profile of the water, which in turn will correlate with biological effects at the molecular, cellular and organismal level. The Potomac River watershed represents an ideal microcosm for testing this hypothesis. Beginning in 2002, widespread fish kills have occurred in the Potomac and its tributaries, including the Shenandoah River. The cause of these fish kill has yet to be established, although high rates of intersex fish in the area have lead to a focus on endocrine disruption as a contributor to mortality. In August 2014, we deployed in-situ, flow-through aquaria at four locations in the Shenandoah Valley with distinct landuse patterning, including an agriculturally dominated site, a WWTP effluent site, a downstream mixed-use site, and a pristine reference site. Fathead minnows (Pimephales promelas) were exposed to native water sources and sampled at 7 and 21 days of exposure. Water was sampled every seven days for chemical profiling. Gonads were prepared for histological examination and analyzed for cellular and tissue abnormalities. In males, serum concentrations of vitellogenin were measured by ELISA as a biomarker of exposure to estrogenic substances. To link these traditional biomarkers to molecular changes, RNA sequencing will be used to profile transcriptomic changes and identify differentially expressed genes [DEGs] following chemical exposure. Gene set enrichment analysis and sub-network enrichment analysis will identify biological processes and molecular pathways that are statistically over represented among DEGs. To link the transcriptomic profile back to landscape patterning, a principle components analysis will be preformed on the gene expression data. A significant clustering of samples by site will indicate that transcriptomic changes do indeed vary based on watershed. Together, these data will provide novel insight into the relationship between landuse, chemical contamination and biological effect.